Managing pack ice and icebergs

Avoiding pack ice and managing icebergs was one of the key elements of Cairn Energy's exploration drilling program offshore western Greenland in the summer of 2010. Andrew Safer reports

Iceberg being towed offshore western Greenland by an anchor-handling supply vessel for Cairn Energy.
Credit: Cairn Energy

Cairn Energy, a Scotland-based oil and gas explorer and producer, drilled three wells at approximately 70 north and 60 west, 150 to 200 kilometers offshore in its acreage in the Baffin Bay Basin during a much anticipated Summer 2010 campaign. These were the first wells drilled in the Greenland Arctic in 10 years. The objective was to identify the window of opportunity when the water would be free from pack ice, and to keep icebergs out of the protection zone around the drill site to ensure the exploration program could continue safely and without interruption.

However, by October, Cairn said that its initial finds offshore Greenland were too small to commercialise, but that exploration in the area is at a very early stage and consequently to have encountered both gas and oil in two of the first exploration wells in the previously undrilled Baffin Bay geological basin remains 'extremely encouraging'.

The planning for this exploration program included hiring two rigs to explore together; hiring 14 support vessels including helicopters, warebarges for accommodating crew, emergency response, and iceberg management vessels; designing the drilling schedule so that only one rig entered a hydrocarbon-bearing section at a time; a well design with primary and secondary barriers to minimize the possibility of an uncontrolled release of hydrocarbons, reviewed in accordance with North Sea practice; and pre-operations and fortnightly testing of the blowout prevention equipment by both Cairn and independent authorities.

In addition, Cairn contracted C-CORE and Provincial Aerospace Limited (PAL) of St. John's, Newfoundland & Labrador "because they met the necessary technical, health and safety and commercial terms," said Ellie Goss, Cairn Energy's Corporate Affairs Manager. "They have experience providing successful iceberg and ice management services in similar climates to other members of the oil industry. These practices have been used for at least 30 years off the east coast of Canada where there is a thriving oil and gas exploration and production industry." Cairn also contracted Cougar Helicopters of St. John's to provide helicopter support for the offshore operations.

Charting history

To assist Cairn in planning their drilling program, in March 2009, C-CORE began gathering historical iceberg and pack-ice data by analyzing approximately 200 satellite images dating back to 2004. On board a 45-metre converted fishing trawler, in July PAL's observers began a field observation program, photographing and collecting information on the length, width, height and drift patterns of icebergs. To gauge the accuracy of using the historical satellite images to identify icebergs, each day, C-CORE sent PAL's observers a defined geographic area (four corners of a box) and the observers sent back a plot showing the icebergs they observed. C-CORE then processed that day's modern high-resolution satellite imagery for that area, and compared their findings to PAL's iceberg plot. According to Des Power, C-CORE's Director for Radar and Vision, the positive targets derived from the satellite images were between 95 and 100 per cent accurate, depending on weather conditions. Based on this, C-CORE calculated an adjustment factor and applied it to the historical low-resolution

Coordinated by a Provincial Aerospace Ltd. observer, a water cannon is being used to change an iceberg's trajectory on the Grand Banks, Newfoundland.
Credit: Provincial Aerospace

(and less accurate) satellite images to determine a best estimate of seasonal and annual variability which is necessary for decision-making.

"Cairn wanted to know what kind of icebergs were up there, and also the reliability of the satellite data," explains Carrie Young, PAL's Assistant Operations Manager, Environmental Services Division. The historical satellite imagery analysis and field observation data in 2009 provided a sound basis for planning ice management operations for the 2010 drilling operations. PAL and C-CORE submitted an ice management plan to Cairn, which included a recommendation for six ice management vessels [anchor-handling supply vessels were provided).

During the drilling program, on average, PAL coordinated the management of one to two icebergs per day. Historically, an iceberg's average speed is ½ knot but in heavy weather conditions it can travel at up to 3 knots. The drift direction is determined by constantly changing sea and wind conditions, as well as "tidal looping", whereby tide change moves the iceberg in a loop pattern over a 12-hour period.

PAL's ice observers entered the iceberg information into the company's proprietary Ice Data Network System (IDNS), a geographic information system and database PAL used to generate reports for Cairn.

Stena Don into action

In June, C-CORE provided PAL and Cairn with maps of icebergs and pack ice that could potentially affect operations. In late June, when the region was clear of pack ice, a fifth-generation semisubmersible DP rig, the Stena Don, was brought onto location.

To ensure that the rig had a clear path to the drill site, C-CORE used satellite imagery to identify positive targets along the route in Arctic waters and PAL observers coordinated iceberg-towing operations in the vicinity of the drill site. In July, the sixth-generation drill ship Stena Forth was moved into position at a second drill site 22 nautical miles from the Stena Don.

During the drilling program, PAL's observers served 12-hour shifts on the rigs and coordinated operations on six ice-management vessels. For iceberg detection, the ice observers used specialized ice radar developed by Rutter Inc. of St. John's, and began directing ice management operations when the icebergs were 20 miles from either rig. Aerial reconnaissance wasn't necessary because the facilities were dynamically positioned and the zones were relatively small. The ice observers compared forecasted weather conditions to observed conditions, and historical iceberg movement to observed movement to determine which icebergs needed to be managed. Based on the iceberg's size, shape, stability and towability, it was either towed with a net or a rope, or a water canon or prop washer was used to alter its trajectory.

If the iceberg was large and stable, either one or two vessels towed it using a rope, in which five sections of 400-meter floating fiber rope are connected to the vessel's work wire.

The net, developed by C-CORE in 2003 to improve iceberg towing on the Grand Banks offshore Newfoundland, was the preferred method for icebergs that were rolling or unstable, as the rope can slip off. "The goal is to capture and control," explains C-CORE's Director for Ice Engineering, Freeman Ralph. "so you use a catcher's mitt instead of a slingshot: the pocket created by the net gives you more control." The net is fitted on the iceberg below the water line. C-CORE provided engineering support for equipment design and modifications.

Growlers and bergy bits

If the iceberg is small (known as a 'growler' or 'bergy bit'), vessels equipped for fire-fighting can use water canons to pump seawater at the base to create a localized current that changes the berg's drift direction. Similarly, prop washing (when an ice management vessel backs up close to the berg, applies full power, and creates a wash from the propellors) can be used to create a localized current. These "pushing" actions can be repeated until the iceberg changes direction. PAL's Young notes that one vessel on the Cairn project that had azimuthing azipod thrusters was very effective in this capacity.

During Cairn's three-month drilling program, PAL coordinated ice management operations on 143 icebergs. Due to ice detection and management services information provided by the PAL / C-CORE team, Cairn's key objective was met: no pack ice was encountered during the drilling program, and neither the Stena Don nor the Stena Forth had to disconnect and move to another location due to icebergs.

Ice expertise

Headquartered at the edge of the North Atlantic in St. John's, Newfoundland and Labrador, C-CORE has been providing ice engineering services to the offshore oil and gas sector since the mid-1970s, and Provincial Aerospace Limited (PAL) has been providing ice management services to the sector since the late 1970s.

C-CORE is a specialized engineering corporation that conducts applied R&D in radar and vision systems, ice engineering, and geotechnical engineering. Their offshore oil and gas team of 17 ice engineers and scientists, eight remote sensing specialists, and six geotechnical engineers is believed to be the largest such team in the world.

C-CORE provides ice engineering services in all regions of the Arctic and sub-Arctic including: detecting and monitoring sea ice, icebergs, and icebergs in pack ice; managing icebergs and icebergs in pack ice; determining the risk sea ice and icebergs pose to offshore structures and ships, seabed installations, and pipelines; monitoring pack ice, iceberg, and atmospheric ice conditions, and determining the design impact forces of icebergs and pack ice on offshore structures and ships.

Iceberg detection

After Radarsat 1 became operational in 1996, C-CORE began investigating the use of satellite imagery for iceberg detection. The launch of the European satellite Envisat in 2002 introduced polarization which vastly improved the ability to distinguish icebergs from vessels. Then in 2007, a new constellation of satellites from Italy and Germany and Canada's Radarsat 2 began providing much higher resolution and superior filtration of noise and sea clutter which boosted the probability of detection from 70% to over 95%. Satellite images cover up to a 500-kilometer swath, compared to radar that can see from 20 to 38 kilometers out to the horizon, depending on elevation.

After acquiring the images in a given area of interest, C-CORE processes them to separate out the vessels and potential noise and sea clutter, and characterizes the iceberg distribution. Based on this information the operator knows what to expect regarding iceberg activity at a given location, either before a lease is purchased or to assist in the planning of drilling operations.

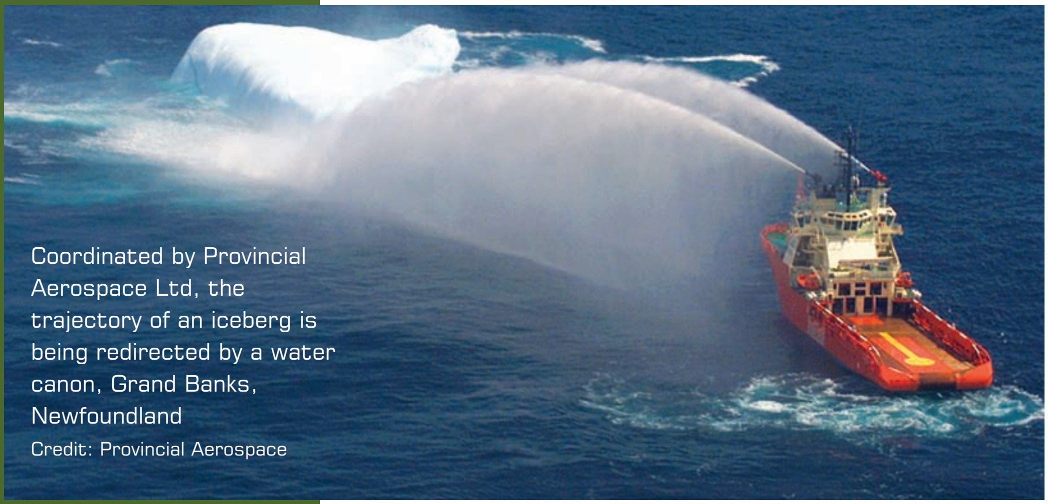
Envisat satellite images became available at no cost in 2009, whereas many satellite images had cost between $1,000 and $5,000 previously. "The value of satellite images is only seeing the light of day in the last couple of years," notes Freeman Ralph, C-CORE's Director of Ice Engineering. "Before, it would have cost up to $500,000 to access 100 images. Now, when companies come to us expecting all the answers, the economics fit within the expectations of the industry."

Design specification for offshore structures

Five oil and gas companies interested in leasing acreage offshore Greenland have engaged C-CORE to provide them with a preliminary design basis of the historical and expected ice conditions. C-CORE prepares environmental and engineering specifications for design, indicating how often ice can be expected to interact with the facility, the nature of the interaction forces and risk mitigation strategies. The specification identifies the global forces for the moorings and local forces for hull design.

In the case of a gravity-based structure, such as the one C-CORE is specifying for the Hebron development on the Grand Banks, the specification pertains to the global forces for sliding resistance, overturning moment, and concrete caisson design. Based on the historical and expected distribution of icebergs in the area, a topsides elevation is also specified.

White Rose project on the Grand Banks.



Coordinated by Provincial Aerospace Ltd, the trajectory of an iceberg is being redirected by a water canon, Grand Banks, Newfoundland

Credit: Provincial Aerospace

Keeping watch on growlers

A chilly view from the bridge, offshore Newfoundland
Credit: Provincial Aerospace

Since the late1970s, Canada's Provincial Aerospace Limited (PAL) has conducted ice reconnaissance missions and ice management operations on the Grand Banks, approximately 180 nautical miles east-southeast of St. John's, Newfoundland and Labrador for Hibernia Management Development Corporation, Petro-Canada/Suncor, ExxonMobil Canada, Husky Energy, Norsk Hydro, and Chevron Canada Ltd.

The ice season begins in early March when icebergs embedded in sea ice typically begin to encroach on the Grand Banks. Focused on latitudes south of 48, PAL pilots flying ice reconnaissance missions in Super King Air aircraft follow a pre-determined grid pattern over the northern Grand Banks. Referring to drift models in PAL's Ice Data Network System, the observer accompanying the pilot uses radar to identify and plot the position, size and shape of icebergs, and the concentration, age, floe size, speed and direction of pack ice, as well as the ice edge.

Once the water is free of pack ice, drilling operations resume. The ice season runs until the end of April when the pack ice melts and the icebergs which are released float freely until July.

PAL's ice and weather observers on the offshore production facilities take photographs and plot data which is reported to the contracted weather forecaster who does site-specific forecasts for the operators. In the winter, PAL staff have measured winds in excess of 115 miles per hour and wave heights in excess of 30 metres. The marine weather data is also communicated to Environment Canada and is included in their weather analysis for national and international mariners. PAL assembles the ice reconnaissance and weather observation data into a package that is delivered each day to the operators and offshore ice and weather observers.

Observers also do aviation observation in support of offshore helicopter operations, monitor seabird and mammal activity within the visual field of the rigs, and coordinate iceberg management activities.

Icebergs range in size from growlers (the size of a refrigerator: less than one meter high, five meters in water line length, and about 1,000 tons) to very large (over 75 meters high, 200 meters in water line length, and greater than 10 million tons).

PAL observers are trained at the Centre for Marine Simulation and the Offshore Safety and Survival Centre at the Fisheries and Marine Institute of Memorial University in St. John's, where they are licensed to operate VHF and GMDSS systems.

Pat Barron, PAL's Operations Manager and Quality Assurance Manager, started working for the company as an ice and weather observer off the coast of Labrador in 1979. He reports that in 2010 there were no icebergs on the Grand Banks due to elevated sea temperatures and drift patterns that kept the icebergs shore-based on the Labrador coast. "Icebergs survive in pack ice, which keeps them from melting," says Barron. "As reported by Canadian Ice Services, there hasn't been a year with as little pack ice on record." In 2009, PAL tracked over 600 icebergs in the area.

Asked if any of the operators on the Grand Banks has ever had to cease drilling operations due to an iceberg, Barron replied, "Neither Terra Nova nor the Sea Rose (the two floating production units) has ever had to move, and Hibernia hasn't had to stop operations."

Outside the Grand Banks, PAL has provided ice management services in the Davis Strait and off coastal Labrador, and for ExxonMobil Canada, EnCana, and Canadian Superior offshore Nova Scotia, and Cairn Energy PLC offshore western Greenland.