Development of a Decision Support Tool to Aid Iceberg Management Operations

Jon Bruce[1,4], Renat Yulmetov[1], Tony King[1], Freeman Ralph[1], Adel Younan[2], Chris Warren[3]
[1]C-CORE, [2]ExxonMobil-Upstream Integrated Solutions, [3]ExxonMobil Canada
[4]Corresponding author: jonathon.bruce@c-core.ca

Abstract

Icebergs present a significant design challenge for operators on the Grand Banks of Newfoundland. The use of iceberg management, iceberg towing in particular, significantly reduces the risk of iceberg impacts with offshore structures. A decision support system is being developed to assist with iceberg management operations. Iceberg management is currently carried out without knowledge of the underwater shape of the iceberg. The system integrates the rapid generation of 3D iceberg shape data and a collection of tools that utilize the data to provide recommendations, intended to improve iceberg management effectiveness. An interface has been developed to de-noise the collected data and correct it for drift and rotation of the iceberg. Tools have been developed to assess the stability of the iceberg, and to consider the shape of the iceberg relative to towing net dimensions, to provide guidance to the operator regarding the recommended towing direction to avoid iceberg rolling or net slippage events. Other applications of the profile data include an impact loads analysis tool that determines the distribution of potential iceberg loads in the event of a collision with a given platform, and an operational iceberg drift model that uses the iceberg shape to improve iceberg drift forecasts.

Introduction

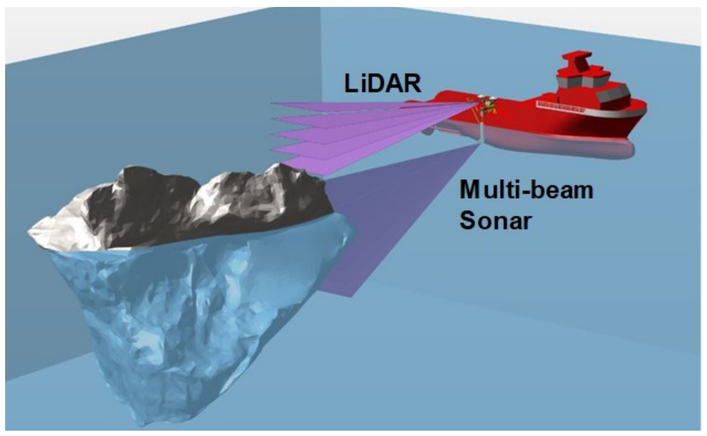
Icebergs present a significant design challenge for operators on the Grand Banks of Newfoundland. Icebergs present a risk to surface piercing structures, such as production platforms or moored offshore drilling units (MODU), as well as subsea infrastructure, such as pipelines and wellheads. The use of iceberg management (iceberg towing in particular) significantly reduces the risk of iceberg impacts with offshore structures.

Improvements to iceberg towing success rates have a number of benefits for offshore operations. The primary benefit is the increased safety for those working offshore. Additionally, ISO 19906 permits the effect of iceberg management to be included in the design of offshore structures, therefore improvements to iceberg management success rates translates into potential reductions in the costs of new offshore structures. Towing an iceberg more efficiently, with fewer attempts required to remove the iceberg threat results in improved vessel utilization and potential reductions in operating costs.

Iceberg management on the Grand Banks of Newfoundland is currently carried out without knowledge of the underwater shape of the iceberg. A decision support tool is being developed to integrate the rapid generation of 3D iceberg shape data with a collection of tools that utilize the data to try to improve iceberg management success rates and efficiency. The iceberg profiling builds on the work done in Younan et al., 2016 and McGuire et al., 2016.

System Overview

The system utilizes a LiDAR and a multibeam sonar to profile the iceberg sail and keel, respectively. The multibeam is currently deployed over the side of the vessel using a hydraulically actuated pole assembly. The multibeam is mounted to a 90° elbow such that the orientation of the multibeam is sideways (looking at the iceberg) rather than in the typical downward orientation (looking at the seabed). It should be noted that deploying the sonar over the side of the vessel using the pole assembly is intended as a proof of concept type of installation. A permanent installation would utilize a through hull pole to avoid impacting the vessels regular operations and docking capabilities.



Data Collection & Processing

A vessel equipped with the profiling system circumnavigates an iceberg twice to collect the iceberg shape data, whilst maintaining a safe standoff distance from the iceberg. This process typically takes approximately 15-30 minutes, depending on vessel mobility and iceberg size.

The data acquisition is achieved by using commercially available surveying software. The software is complex and is generally operated by those with a surveying background. For this application, the complex setup work is done when the system is installed on the vessel, and a paired back user interface is used to collect the data in the field. Making it possible for the system to be operated by trained vessel crew as opposed to surveyors.

Drifting icebergs, as free-floating bodies, have three translational and three rotational degrees of freedom. Iceberg translation and yawing are the most significant movements during the profiling process. An iceberg traveling at a speed of 1 knot can move approximately 600 m in 20 minutes. The iceberg may undergo significant rotation during this time also. Therefore, the point clouds appear to be skewed and have to be corrected for drift and rotation .

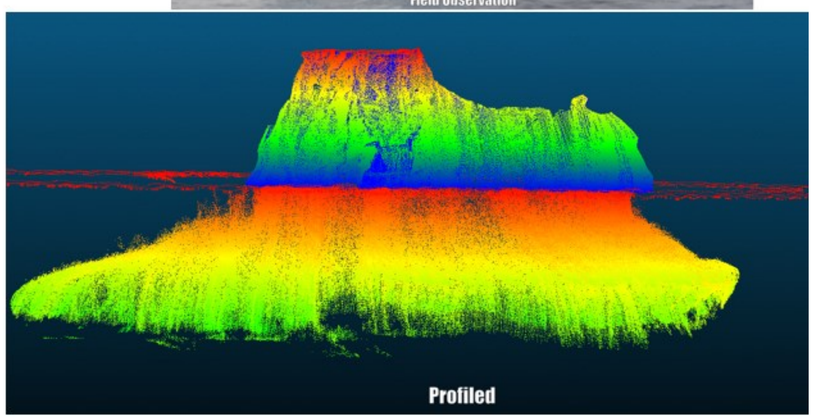
The data must be further processed to remove noise. Noise is considered to be any registered point that does not belong to the iceberg surface. A graphical user interface (GUI) has been developed which allows the user to correct the point cloud for iceberg drift and identify and remove noise from the dataset.

Iceberg Profiling Hardware

The LiDAR system used for the program was a Teledyne Optech Polaris LR which was paired with an Applanix POS MV Wavemaster inertial navigation system. The multibeam system use for the program was an R2Sonic 2026 sonar which was paired with the same Applanix POS MV Wavemaster inertial navigation system. The multibeam system was installed on the hydraulically actuated pole assembly which was used to raise and lower the sonar into the water.

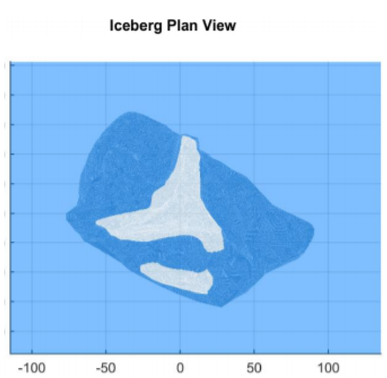
Iceberg Profile Data

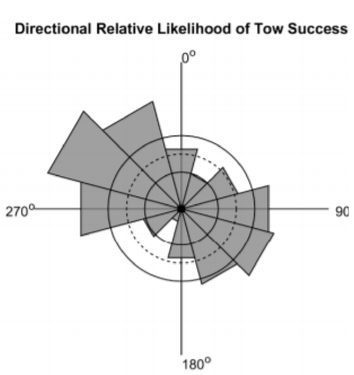
Large scale iceberg profiling field programs took place in both 2018 and 2019 off the coast of Newfoundland and Labrador. The 2018 program took place on an anchor handling supply tug vessel and had a duration of 9 days. The 2019 program was carried out onboard a 100ft long fishing vessel and had a duration of 42 days, carried out over three two week long voyages. During the 2018 program, 18 icebergs were profiled, and during the 2019 program an additional 132 icebergs were profiled. This represents a significant increase in the database of available high quality 3D iceberg profiles. See Bruce et al., 2020.



Iceberg Stability Tool

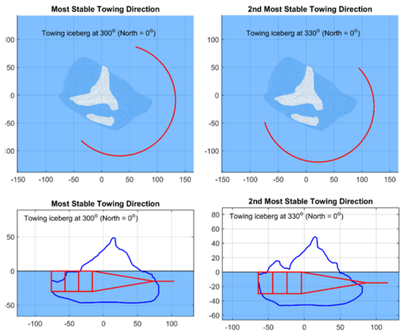
Decision support tools have been developed which can be used to provide guidance to the captains of towing vessels regarding the direction the iceberg should be towed in order to increase the likelihood of towing success. The iceberg stability tool uses the profiled iceberg shape and identifies the directions that are most stable in which to tow the iceberg in order to reduce the frequency of iceberg rolling events. See Bruce et al., 2016.

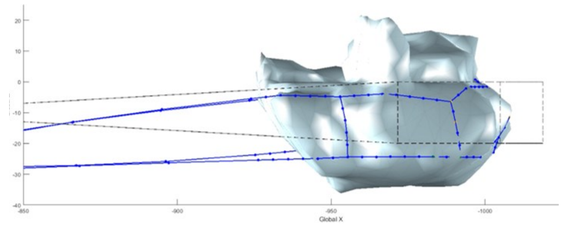




Towing Net Fit Tool

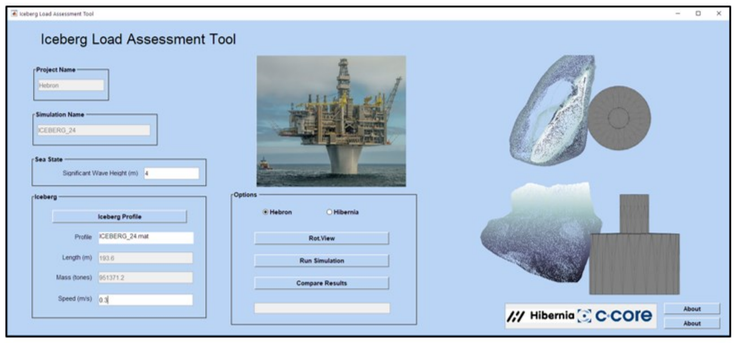
The towing net fit tool, in it's more basic form, provides a visual comparison of the iceberg shape relative to the shape of the iceberg net. The tool is intended to help identify underwater rams or unfavorable iceberg slopes to decrease the frequency of net slippage. The tool uses the output from the stability tool to show the relative net fit for the most stable towing directions. Further development of this tool has focused on using finite element methods to model the way in which the towing net wraps around the iceberg in three dimensions. See Bruce et al. 2016 and O'Rourke et al., 2020.

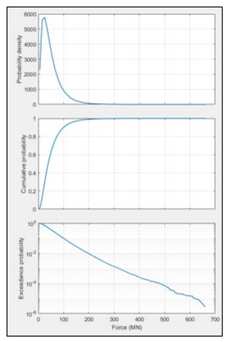




Iceberg Load Assessment Tool

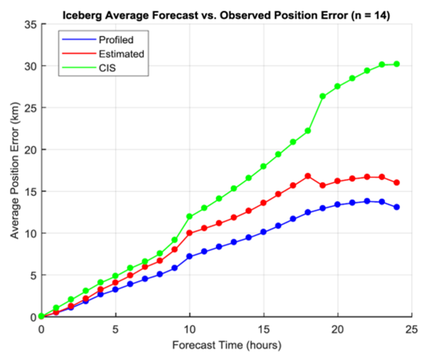
The iceberg load assessment tool has been developed to utilize a profiled iceberg shape to estimate distributions of iceberg impact actions as a result of that specific iceberg impacting a given structure for defined metocean conditions. The tool has been developed using components of the monte carlo simulation module of C-CORE's Iceberg Load Software (ILS). Any parameters which have not been measured can be treated as random parameters selected from distributions and relationships developed based on the general population of icebergs. See Stuckey et al., 2018.





Operational Iceberg Drift Forecast Tool

C-CORE has developed an operational iceberg drift forecast model that outperforms the Canadian Ice Services (CIS) model which is the current industry standard. The C-CORE model utilizes on-site ADCP current measurements to initialize the model and a localized ocean current forecasting scheme rather than the CIS operational community ice-ocean model (CIOM). Additionally the profiled iceberg shape can be used to significantly improve the drift forecast performance. See Turnbull et al., 2018.



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Acknowledgements

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