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ON THE DEVELOPMENT OF AN ICEBERG MANAGEMENT PLANNING AID

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ABSTRACT

Planning iceberg management activities for facilities located in bergy waters is an important aspect of the ice management process. When an iceberg has been identified as a possible threat to offshore facilities, the offshore installation manager (OIM) must decide which vessel should be tasked to carry-out towing operations, the direction to tow and the amount of bollard pull to apply, given the existing set of environmental and operational conditions. If several icebergs are considered threats, planning management strategies can be difficult without some sort of aid. This paper gives an overview of iceberg management planning software developed to improve the effectiveness of iceberg towing operations and reduce the possibility of downtime for a facility. Results of bench-testing are presented and future development plans indicated.

INTRODUCTION

Background

In recent years, oil and gas activity in ice infested waters has increased dramatically. With such increased activity has come the need for effective iceberg management. Physical management is generally achieved by encircling an iceberg with a floating towline connected to a supply vessel and pulling it away from an anchored or stationary platform. Iceberg towing efforts are undertaken by tugs or supply vessels with various capabilities, often with no clear expectation as to the outcome. Successful and efficient iceberg towing operations on the Grand Banks of Newfoundland are important for the safety of offshore drill rigs, production platforms and personnel aboard them, as well as for reducing tow vessel fuel consumption and the risk of environmental disasters due to iceberg collisions with these installations.

With two oil production sites on the Grand Banks (Terra Nova and Hibernia) and plans for additional production and exploration, the need for strategic planning of tow operations is critical to the safety of all systems in the area. Prior to developments described in this paper, no formal tool has been available to quantitatively and effectively plan iceberg towing operations.

A first generation iceberg management planning aid (IMPA) algorithm was developed by P.E. Dunderdale and Associates Inc. and tested by C-CORE for engineering principals and accuracy (C-CORE, 2000). The algorithm was subsequently transformed into a simple stand-alone software application. This early version was considered a base from which a full-featured software package could later be developed.

The model takes user input regarding iceberg size, shape, free drift velocity and direction, along with applied tow force and direction and general site-specific details to compute the expected iceberg drift outcome.

The present form of this application is a complete rewrite of previous versions, allowing for iceberg management planning for any number of icebergs and installations in a given region and provides many tools common in current commercial software packages.

Industrial Benefits of Tow Planning

With better planning of iceberg towing operations, towing effectiveness will be enhanced. Not only would risk to personnel safety be decreased, but also risk to the environment and obvious financial risks reduced.

The potential for IMPA to provide financial benefits becomes apparent when one considers the immense costs associated with downtime and disconnection of drilling and production facilities as a result of an iceberg threat. A drill rig on the Grand Banks typically costs approximately $350,000 per day. If downtime is initiated, costs could easily escalate beyond $1M, depending on the amount of time operations are suspended. The approximate daily cost for disconnection of the Terra Nova FPSO, in terms of lost production, is $6M (150 000 bbl/day at ~$CAD40 /bbl).

As the number of facilities on the Grand Banks increases, ice management logistics become more complicated. Numerous structures need to be protected, both on the seabed and the surface. Use of IMPA will lead to better planning of iceberg towing operations and vessel efficiency. It could be used as a planning management tool to determine strategic requirements during the ice season. Optimizing vessel utilization may lead to reduced requirements and hence significant cost savings, including ($20k to $40k per day) for a single ice management vessel.

THE MATHEMATICAL MODEL

The model predicts iceberg deflection under tow, based on a sum of the force vectors involved. Since detailed real-time information is usually not available regarding iceberg underwater shape and ocean currents, the model does not rely on these data. The assumption is made that environmental conditions causing the free drift of the iceberg will remain constant within a reasonable time frame from the last position recorded. A calculation is made to estimate the drift force of the iceberg, based on a modification of standard towing formulae (Dunderdale, 1997). The iceberg drift force is equivalent to the net force required to drive the iceberg at the observed drift velocity. By calculating the drift force vector and applying a tow force vector the resultant is calculated to give the towed drift vector.

Model inputs and outputs are summarized in Table 1. Output from the model predictions of tow deflection are displayed graphically in the software for more effective methods of planning ice management operations. Values such as closest possible approach, course and speed made good, velocity under tow, and time required to reach maximum deflection are also displayed to the user for planning management operations. A graphical definition of several variables, including closest possible approach, is given in Figure 1.

Table 1. Input and output parameters of IMPA.

Input Parameters		
Ship	Name, latitude, longitude, heading and tow force (if towing)	
Ice	ID, shape, length, width, height, free drift speed and direction, latitude and longitude or range and bearing, date and time	
Installation	Name, latitude, longitude, water depth, hazard circle size	
Output parameters		
Parameter	Definition	Units
CPA	Closest possible approach to the installation (Figure 1)	nmi
TCPA	Time required to reach the CPA	h
CMG	Course made good - heading at maximum deflection angle	°
SMG	Speed made good – speed at CMG	kts
TCMG	Time to reach CMG	h

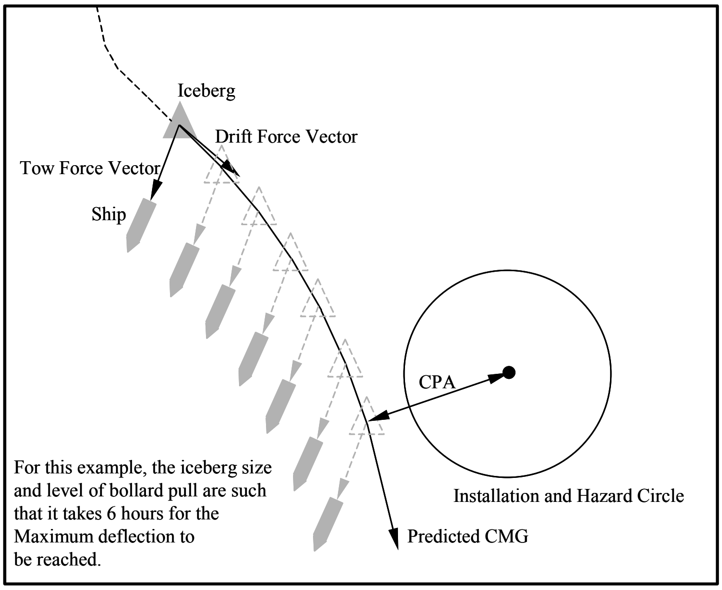

Figure 1. Definition of example CPA calculation based on time required to reach CMG.

THE GRAPHICAL USER INTERFACE

The graphic user interface (GUI) is an important aspect of IMPA by providing field users with important visual feedback of current conditions and predictions, and allowing for easy user interaction with the mathematical model.

Standard software development techniques were employed in the development of the software package. Prior to development of the interface and coding, a software requirements specification (SRS) document was created to outline the requirements of the application. Also, unified modelling language (UML) diagrams (Figure 2) and traditional flowcharts (Figure 3) were developed to identify the static and dynamic interactions between the main application components and identify the key software classes.

The IMPA GUI is divided into three main regions – the properties, graph and menu/toolbar views. Figure 4 depicts the IMPA operating environment, including the three GUI regions. The graph view displays a graphical representation of the iceberg, installation and ship information entered into IMPA. The properties view displays all relevant information about the objects shown in the graph view and is divided into four separate tabs – Ice, Ships, Installation and Predictions. The menu/button bar provides the tools and functions available as part of the software, such as adding new icebergs, ships and installations, or changing the properties of any objects in the graph view. The user is also provided with a zoom feature and a tool for measuring the distance between two points.

The user can also interact with the graph view objects (ships, icebergs, installations and predictions) through mouse gestures on the graph view. For example, manipulating the properties of a ship can be carried-out by double-clicking on the object and modifying the data displayed in the dialog box for that object.

The graph view displays information in a latitude, longitude coordinate system that is based on a standard Mercator projection of the curved earth surface. The user is able to specify the location of objects using either latitude, longitude coordinate pairs or by specifying a range and bearing from an installation. A standard file input and output facility is available for users to save and load scenarios.

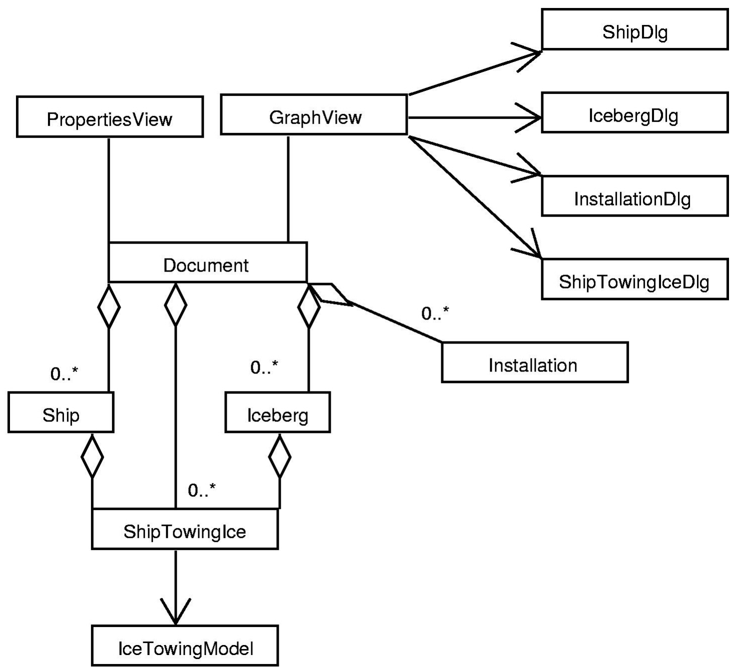

Figure 2. A UML class diagram of the main application classes.

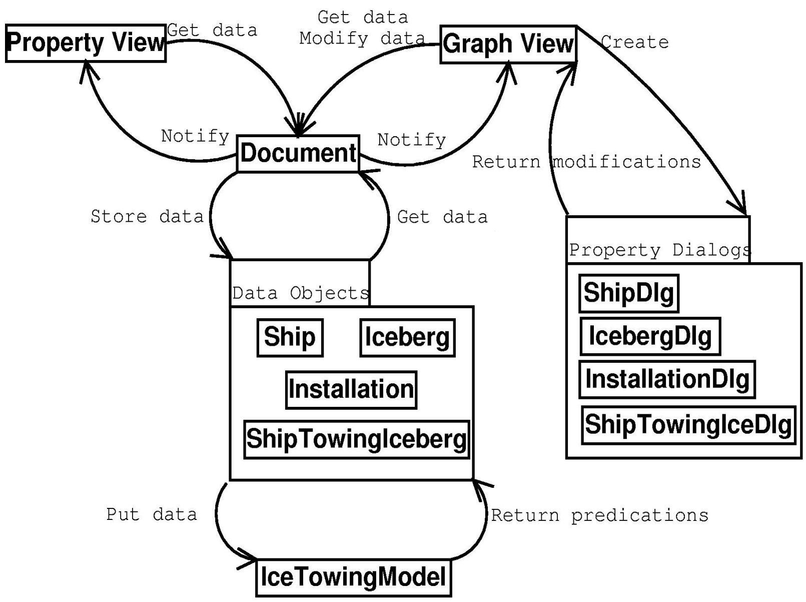

Figure 3. An illustration of the high level interactions between the main application components.

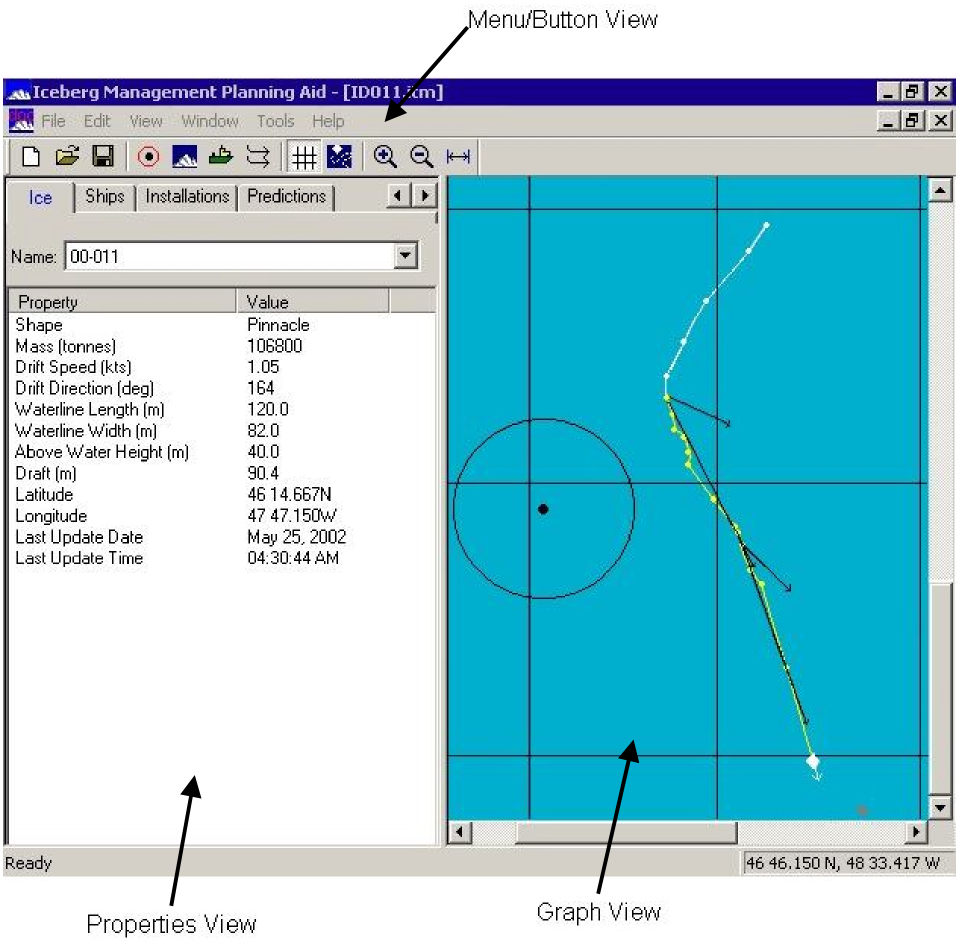

Figure 4. Sample screen from IMPA.

BENCH TEST RESULTS

IMPA has been bench-tested using most of the suitable historical tow data compiled from the late 1970s to 2001 (C-CORE, 2001). For these analyses, the input data were compiled from a database for a total of 159 tows on 137 icebergs. An example test plot is shown in Figure 5. Since this testing procedure involved using historical data, the results relied heavily on the accuracy of the data. In some cases, data were considered to be unreliable and not useful for bench testing. Questionable data were considered to be:

- unrealistically high bollard pull compared with iceberg size;
- tow data and results inconsistent with previous tow results under the same conditions; or
- crew comments not consistent with data presented.

An example of a questionable dataset is given in Figure 6. For this case, a bergy bit was reported as being towed for 7 hours with a very large bollard pull for that size of iceberg, resulting in no change in drift direction. In addition, environmental conditions should have helped move the iceberg in the direction of tow. For this reason, the analysis of this tow was not included in the overall assessment. If questionable data are removed from the assessment (30 out of 159 total), on average the model predicts SMG to within 0.5 kts (below 0.25 kts error 60 % of the time) and CMG to within 24 ° (below 15 ° error for 65 % of the time).

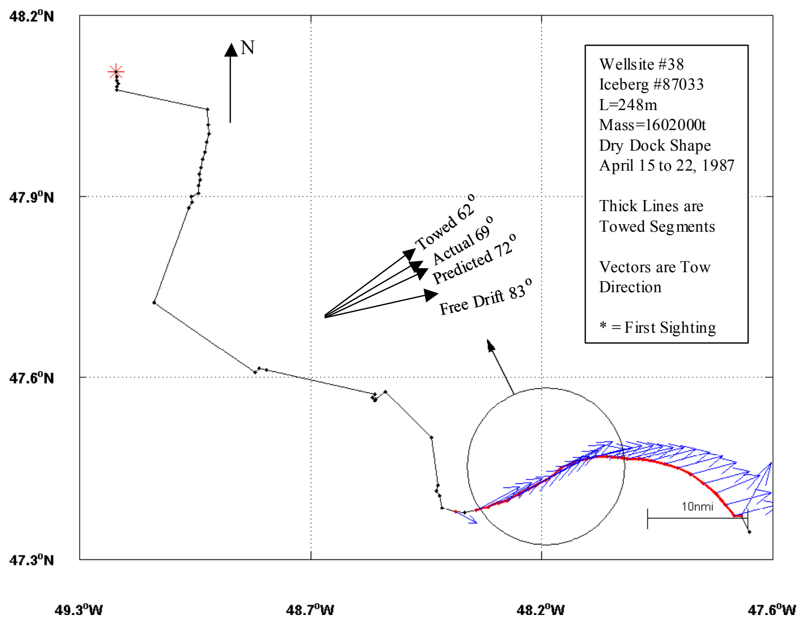

Figure 5. Drift track for Iceberg #87033 on the northeastern Grand Banks showing accuracy of the prediction.

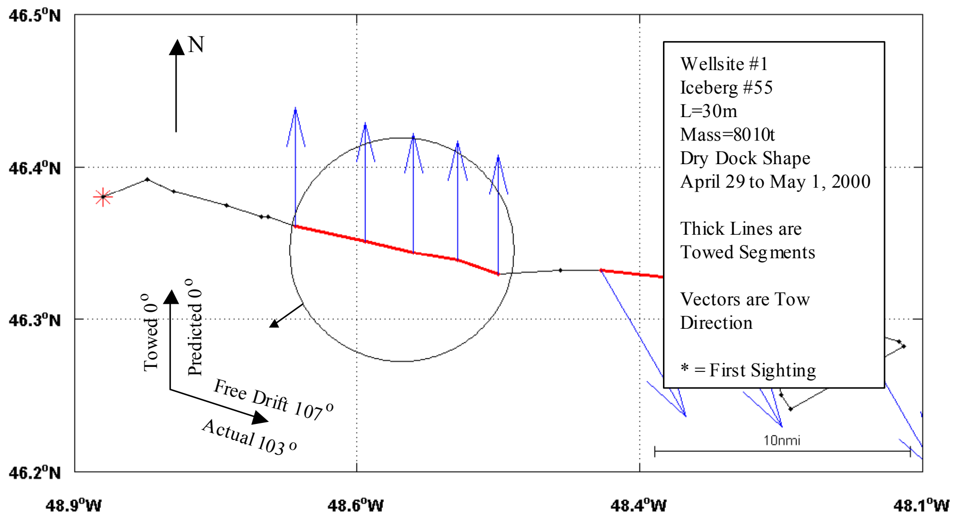

Figure 6. Drift track for Iceberg #00055 on the northeastern Grand Banks showing accuracy of the prediction.

THE FUTURE

Due to the nature of software development, a significant number of recommendations can be made for future work, including interface and model improvements. Some of the more valuable recommendations are made here.

Using local bathymetry and iceberg draft, a check will be performed to determine if the iceberg is expected to ground during a tow and approximately how long before this will occur. For visualization, bathymetry will be shown in the graph view of the software interface.

Research by C-CORE during 2003/2004 will provide a reliable means for estimating iceberg stability while under tow. Results from this study will be used to make recommendations for the safest level of towing bollard pull to prevent roll of towed icebergs.

As more and accurate data are collected offshore about underwater iceberg shape and metocean conditions, the ability to utilize real-time iceberg drift prediction models will become more accessible. It is expected that the addition of a metocean-driven drift model would improve model prediction accuracy, when these data become readily available and reliable.

Peter E. Dunderdale and Associates Inc. has also developed and tested an algorithm for pack ice management planning. While not a large concern on the Grand Banks, this model would be extremely useful in parts of the world where pack ice ridges are a problem for offshore oil exploration and production. For example, the algorithm has been field tested in offshore eastern Sakhalin Island, Russia to great success. The model was found to be very accurate and helpful for predicting the outcome of pushing operations on large pack ice ridges that could potentially interfere with exploration and production systems in the area. If developed to its full potential, this algorithm could be integrated with IMPA and used commercially in regions such as Western Greenland, the American and Canadian regions of the Beaufort Sea and Sakhalin Island.

CONCLUSIONS

Significant effort has been expended to produce a marketable iceberg management planning aid (IMPA) software package. The application has been developed to operate as a stand-alone executable program in the Windows™ 2000 environment and employs a graphical user interface with common commands and features of Windows™ -based software packages.

Results of bench testing with historical iceberg towing data are quite promising. Using data for 129 tows, IMPA predicts speed made good to within 0.25 kts 60 % of the time and course made good to within 15 °, 65 % of the time.

ACKNOWLEDGEMENT

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