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METHODOLOGY FOR COLLECTING ICEBERG OBSERVATIONS DURING SEISMIC OPERATIONS IN NORTH-EAST GREENLAND

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ABSTRACT

August-October 2014 marked the 4th consecutive season TGS has run 2D seismic acquisition project with an icebreaker in North-East Greenland. The operation in 2014 involved two vessels: the Russian seismic vessel Akademik Shatskiy acquiring 2-dimensional seismic data lead by the Finnish icebreaker, MSV Fennica. The operation, taking place in a challenging area with the presence of both multi-year ice and icebergs, required onboard support of ice advisers to ensure a safe and efficient execution of the project. The ice advisory team was also responsible for an extensive ice & metocean data collection program. One of the data sets focused on iceberg data: location, picture, classification, and dimensions. This article describes the methodology developed and used the by ice advisers to record dimensions of icebergs derived from pictures taken from the bridge of the icebreaker.

INTRODUCTION

The 2D seismic operation in North East Greenland (see Figure 1 for the AOI) has mainly been conducted in ice infested waters, and required the vessel pairing's constant movement. Therefore, the primary role of the ice advisers was to support the safety of the operation by analyzing and explaining the ice conditions (helicopter reconnaissance, satellite imagery analysis). However, collecting the ice data was also a significant part of the ice adviser's daily routine. This requires a fixed methodology and standards that easily and systematically can be followed in order to ensure a consistent dataset.
The methodology described in this paper resulted in more accurate iceberg size estimation while the preparation time, and the risk of man-made errors was significantly reduced.
The observations were performed using the facilities of the Ice Office (DMI) that had been installed on the bridge on the icebreaker.

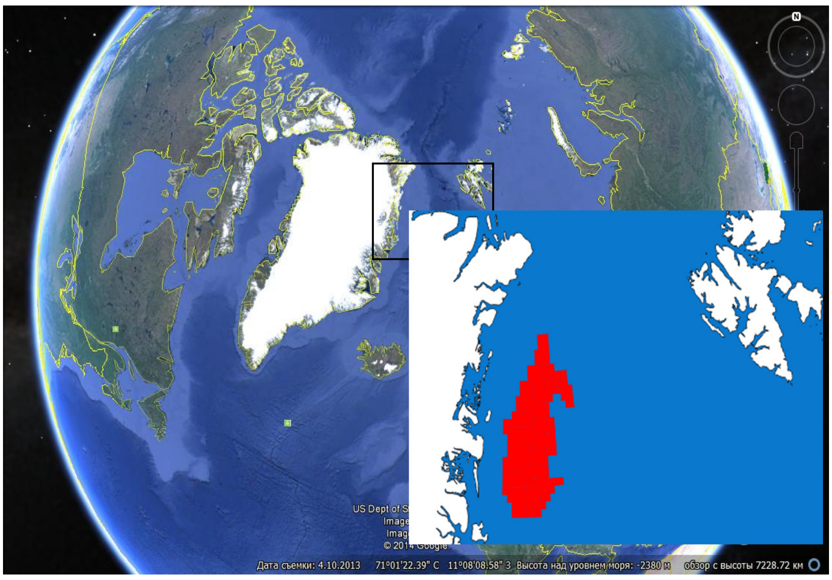

Figure 1 Area of TGS seismic operations NE Greenland.

During previous seasons the methods used for estimating iceberg dimensions were:

- Visual Estimation
- Estimation using binocular scale reading

Visual estimation method

Visual estimation required only a marine radar reading for coordinates (Latitude/Longitude), photo of the observed iceberg. The size of icebergs was described by an ice adviser using Iceberg Size Classification (Table *1*).

Table 1 Iceberg size classification

Size Category	Height	Length
Growler	Less than 1 m	Less than 5 m
Bergy Bit	1-4 m	5-14 m
Small	5-15 m	14-60 m
Medium	16-45 m	61-122 m
Large	46-75 m	123-213 m
Very Large	Over 75 m	Over 213 m

Although the time to complete the observation with this method was minimal, estimating the iceberg size was subjective.

Binocular scale reading method

Figure 2 Example of binocular Scale reading

The binocular scale reading method required an additional parameter – the distance to the iceberg, which was also taken from the marine radar.

Once the iceberg was targeted in binocular, scales for height and width (Figure 2) could be read for further calculation. The formula for calculating the size was taken from the binocular specifications and described by Eq. 1.

$$Object\ Size = \frac{Distance\ \times Scale\ Reading}{1000} \quad (1)$$

The method obviously increased the accuracy of estimating the size of the icebergs, but had its disadvantages – holding the binocular straight to get accurate number from the reading could be a challenging task on the moving vessel as well as to get the decimals, which were quite important if the observed iceberg was several nautical miles away from the vessel.

New methodology for estimating iceberg dimensions

In 2014 the new methodology was introduced to the operation, an approach that avoided most of the disadvantages of the previous methods while increasing the accuracy of the iceberg measurements. This required a picture taken by a digital single-lens reflex camera with CMOS active pixel sensor and the distance to the iceberg.

Using the focal length and known dimensions of the digital camera sensor, the size of an object in the picture is calculated by counting the pixels.

Once the picture of the observed iceberg was taken, it was copied to the shared drive of the Ice Office Workstation. Then, the number of pixels representing the width and height of the iceberg was counted, and finally entered to spreadsheet formula to get the physical dimension of the iceberg in meters.

In order to avoid having various software packages installed to complete the observation (counting pixels, spreadsheet calculation, etc.) and to reduce the risk of man-made errors, an application that was able to process images, feed the iceberg database with the observation and generate an iceberg report was developed by the ice team onboard the icebreaker.

BACKGROUND CALCULATION

The calculation is based on the fact that the pixel's physical dimensions on active pixel sensor of a digital camera can be found by dividing sensors physical dimensions by the amount of pixels sensor holds.

Once the pixels projected on the image, the size of the pixel is magnified by the distance to the object and scaled by the focal length (Figure 3). Finally an object's physical dimensions can by calculated by counting pixels of an object in the picture.

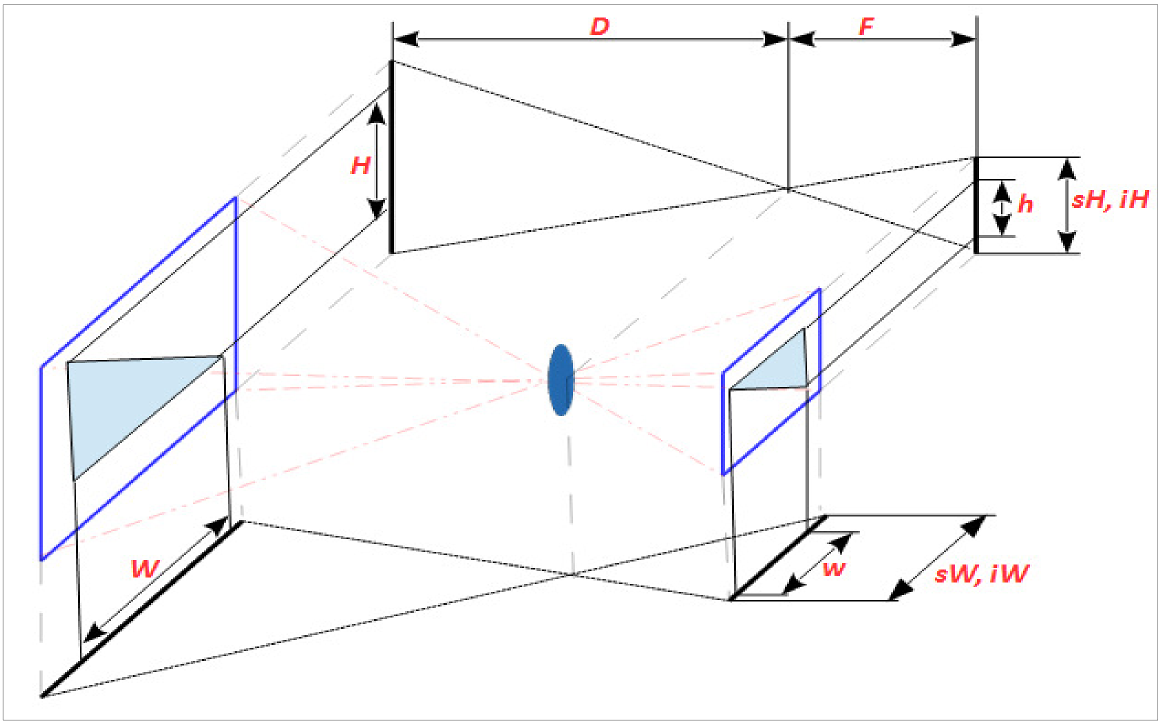

Figure 3 Visualization of the parameters used in the calculation

The parameters shown in the Figure 3 are:

H – Object's height in meters; W – Object's width in meters;

h – Object's height in pixels; w – Object's width in pixels;

sH – Height of camera's sensor in meters; sW – Width of camera's sensor in meters;

iH – Height of camera's sensor pixels; iW – Width of camera's sensor in pixels;

F – Focal length in meters;

D – Distance from camera to an object in meters.

The object's physical dimension calculation can be described by Eq. 2 (Height) and Eq. 3 (Width).

$$H = \frac{sH \times D \times h}{iH \times F} \tag{2}$$

$$W = \frac{sW \times D \times w}{iW \times F} \tag{3}$$

Most accurate result, especially for the height measurement, will be returned if camera hold perpendicular to an object's center, however, due to the safety reasons, icebergs had mostly been observed no closer than 1 kilometer which should make an angle error insignificant.

As the methodology and the software to handle it has been developed "in the field", the evaluation capabilities were limited, although operational evaluation had been done from pictures of the vessels in the area and objects onboard. The evaluation example shown in the Figure 4

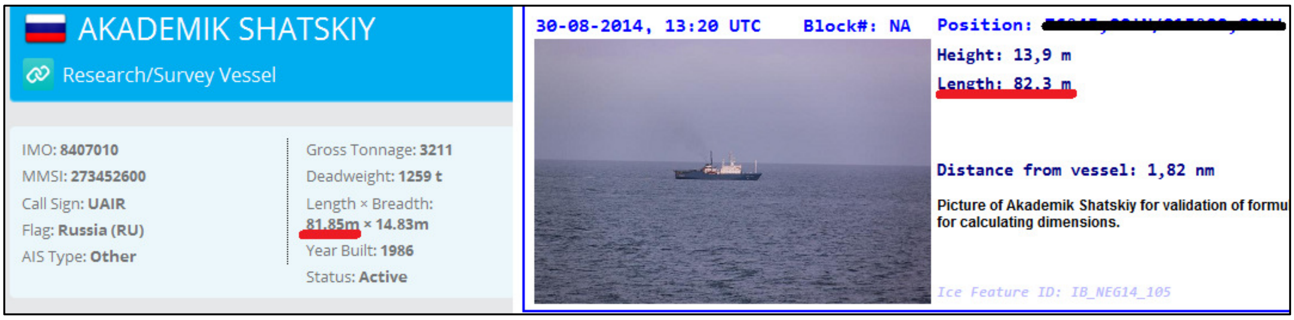

Figure 4 Example of the method's evaluation: Length from the Seismic vessel specification (Left) vs Length calculated from the picture taken from the icebreaker (Right)

APPLICATION AND DATABASE

The methodology required additional tools to complete the observation – graphical software to count pixels, spreadsheet to do the calculation, database to store the observation. Images were previously also stored without being referenced to the database. To optimize the procedures of the iceberg observations, a new application (Figure 5) was developed by the ice team. The application allowed calculating the size of the object based on the picture, entering the observation to the database, arranging iceberg photos and generating report of observed icebergs.

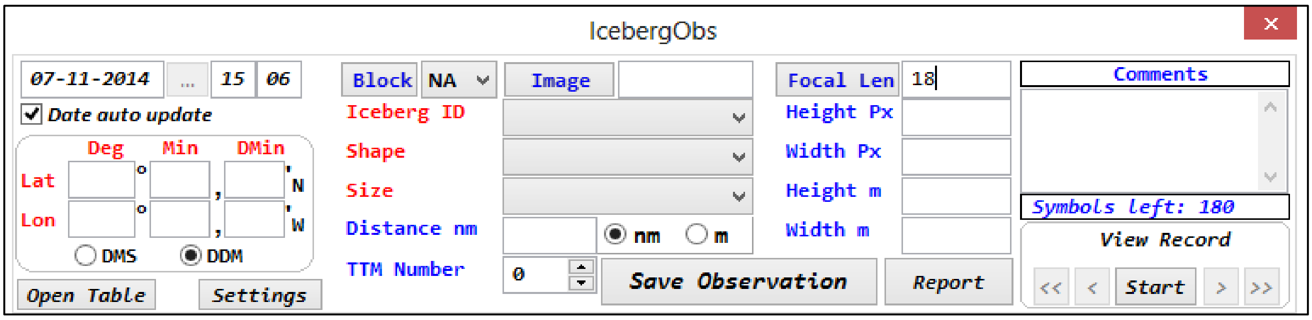

Figure 5 Initial view of the Iceberg Observation Software

Initial settings that will be saved are the sensor physical size (needs only be changed if different camera is used for the observation) and path to the directory where the images are stored. Figure 6 shows distribution of the parameters of the application.

When the photo of an iceberg is taken and the position and distance is written down from the marine radar, the photo will be saved to the assigned directory.
Input Parameters, entered by observer:

- Date/Time
- Geographical location (Latitude/Longitude)
- Image name
- Distance to iceberg
- Iceberg ID (If the iceberg is observed first time, ID will be generated automatically, if the iceberg had been observed previously, the ID will be picked up from the dropdown list)
- TTM Number (If the iceberg is tracked on marine radar, the TTM can be entered to cross-reference tracking data with the observations)
- Shape of the iceberg (classification of the iceberg by shape – Tabular, Blocky, Domed, etc. can be used for future mass calculation)
- Comments, if needed

Focal Length and image width/height in pixels will be extracted from the EXIF properties.

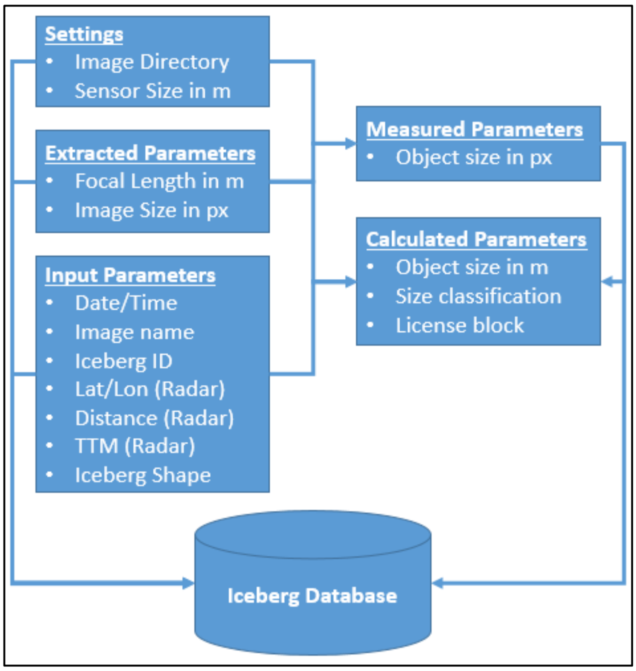

Figure 6 Parameters distribution in the Application

Once input parameters are entered, image will be loaded to the application screen. The amount of pixels of the iceberg is counted by adjusting rectangle (Figure 7) height and width to fit the iceberg. The output parameters will be automatically updated with the adjustment of the rectangle.

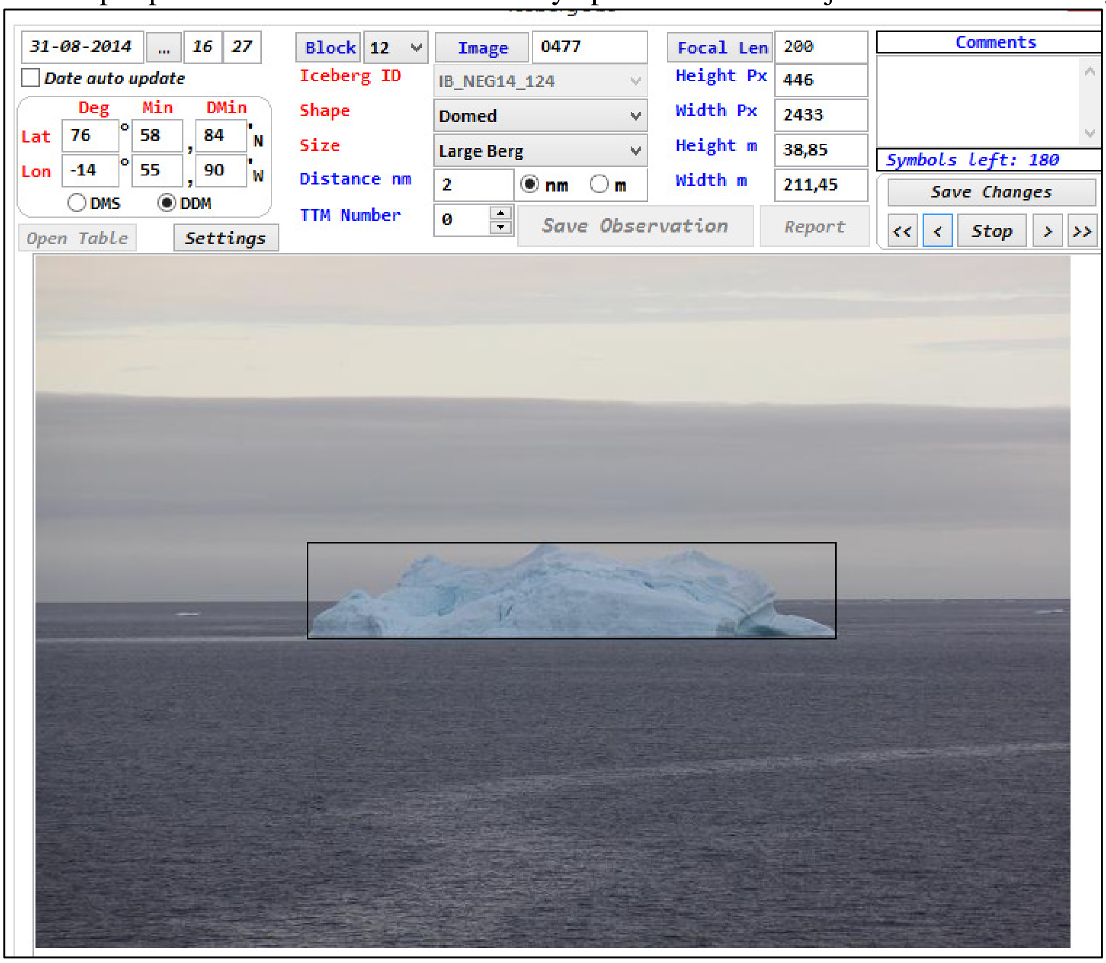

Figure 7 Measuring iceberg's dimension using the software

When the measurement is complete, the observation is saved to database. The application is able to show previous observations in preview mode and adjust measurement or other parameters if needed.

Internal Database

Iceberg observation is stored in the internal database of the application in the “dBase” format. The database is located on the shared drive that is accessed by multiple workstation of the Ice Office. Each workstation has standalone copy of the software, but database and picture folder is shared between them.

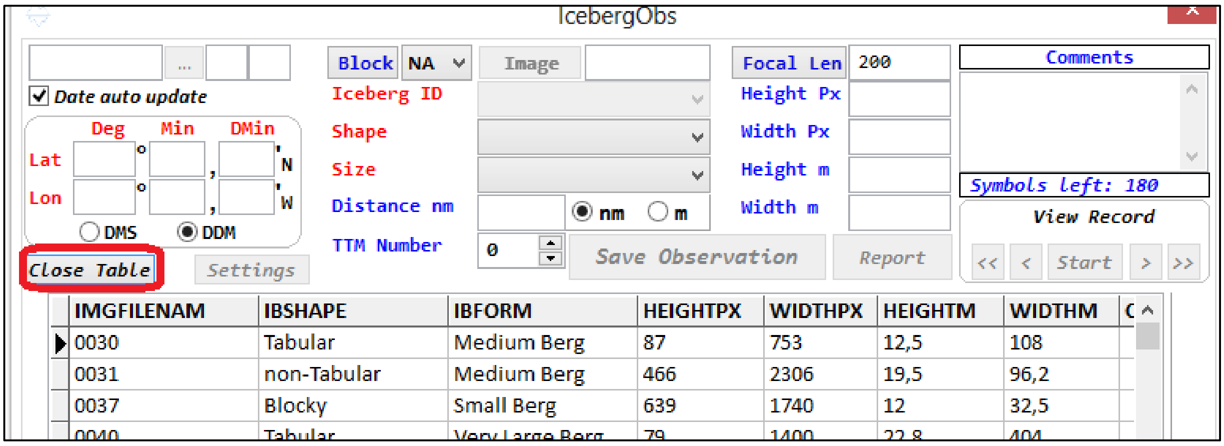

Figure 8 Example of the activated table of the internal database preview

The application is able to generate report (Figure 9) from the database, either based on the all observations or queried with date interval. The report contains compressed pictured of the icebergs observed and the associated iceberg information.

Figure 9 Example of the Iceberg PDF report generated by the software

The report could also help in getting a general overview of the icebergs observed, for instance, to help recognize iceberg previously observed to ensure that the same iceberg ID could be applied.

Spatial Geodatabase

All TGS ice & metocean data (hourly ice & weather observations, ice charts, ice conditions polygons, iceberg observations, etc.) is stored in the spatial geo-database, with automatic dataflow, therefore a sub-process was developed that synchronizes iceberg software internal database with geospatial iceberg feature class of the general geodatabase of the ice office. Once an iceberg observation is made, the sub-process will load the new data into the spatial database, and the newly observed iceberg will appear as a GIS layer on the computer screen, providing various display options, e.g. icebergs with the specified ID could be queried, providing the picture of the iceberg drift (Figure 10), spatial query to get a density of the icebergs observed in each license block, etc.

Figure 10 Sample of Geodatabase usage as a GIS layer

CONCLUSIONS AND RECOMMENDATIONS

The introduction of this method has increased the efficiency and quality of the iceberg records, and enabled more sophisticated analysis for further use of recorded data. The approach allowed reducing observation time to 2-3 minutes, even if there are multiple targets observed. Simple data extraction tool allowed generating PDF reports with one click, and synchronizing it with geodatabase for future spatial analysis.

The methodology could also be applied in the feature operations to measure iceberg polygonal area from the top with camera facing straight down in a gimbal attached to the helicopter (the camera has been used in 2014). The distance to iceberg will be taken from radar altimeter, the height of the iceberg from the difference measured by the altimeter between iceberg and the ocean altitude.

The method will require revision if it will be implemented for analysis of the closer object and the observation angle/observation height coefficients must be than introduced, for example for pile-ups and stamukhi measurement in the Caspian Sea.

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Iceberg observation software development was inspired by Phoenix VT software (by Sean McDermott), that is being used in various offshore operations for ice & weather data collecting and reporting.

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