



# ICE SERVICE REQUIREMENTS QUESTIONNAIRE

## SUMMARY REPORT

September 2009

### INTRODUCTION

During 2006 and 2007, the International Ice Charting Working Group distributed a questionnaire on requirements to the national Ice Services. The questionnaire was developed by Rob Ringrose of Qinetiq Corporation who participated in an IICWG workshop on interoperable data formats. The questionnaire is rather broad in attempting to identify areas where the Ice Services might have common requirements, particularly with respect to accessing and processing satellite image data.

To date, the questionnaire has been completed by ten Ice Services:

- Arctic and Antarctic Research Institute (AARI) (Russia)
- Canadian Ice Service (CIS)
- Danish Meteorological Institute (DMI)
- Finnish Ice Service (FMI)
- German Ice Service (BSH)
- Icelandic Meteorological Office (IMO)
- International Ice Patrol (IIP)
- Japan Meteorological Agency - Office of Marine Prediction (JMA)
- National Ice Center (NIC) (USA)
- Norwegian Ice Service (MET.NO)

Additionally, the British Antarctic Survey (BAS) provided a brief comment on the questionnaire and their service.

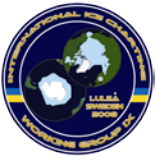
This report summarizes the information provided by the respondents.

### SECTION 1: CURRENT SERVICE

This section of the questionnaire was concerned with establishing the way in which the Ice Services currently operate. The purpose was to try and identify how efficiencies could potentially be achieved through greater collaboration with other Ice Services and how cost savings could potentially be made through bulk purchase of imagery based on data acquisition requirements.

#### THE TYPE OF SERVICE AND FREQUENCY OF IMAGERY ACQUISITION

- All of the Ice Services responding provide a *routine* service requiring monitoring on a regular basis to produce ice analyses daily, twice weekly or weekly (varies with Ice Service).
- Eight of the Ice Services also provide a *real-time* service most frequently described as "navigation support to shipping" that requires repetitive satellite coverage over small areas following shipping in the vicinity of ice



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- The same eight Services also provide a *responsive* service that gives targeted ice analyses in response to an incident or special request. For the relatively small area of the Baltic Sea, this service is coincident with the real-time service provided. Elsewhere, it is described as an infrequent activity.
- One Service indicated that it provides a *tailored* service for specific offshore activities.
- The BAS indicated that it does not provide its own analyses of ice conditions but collects relevant information freely available on the Internet and sends it to the ships it supports, primarily by e-mail.
- Of these service categories, routine monitoring requires the greatest volume of imagery – approximately 60%. Real-time services comprise about 35% of the imagery volume while other service categories account for the remainder. This breakdown should be considered very general however since there is considerable multiple use of images.

### POTENTIAL TO SHARE IMAGERY ACQUISITION COSTS WITH OTHER ICE SERVICES

There are several areas of overlapping responsibility in which Ice Services could potentially reduce their costs by sharing imagery. Of course, this would require appropriate license permissions from the satellite data distributors but is an area that could be explored.

The most significant areas of overlap identified from the questionnaires are:

- Baffin Bay – Davis Strait: IIP, CIS, DMI
- Nares Strait – waters around Ellesmere Island: CIS, DMI
- Labrador Sea: CIS, IIP
- Waters around Cape Farewell: IIP, DMI
- Denmark Strait – Fram Strait: IMO, DMI, MET.NO, AARI
- Greenland Sea – Lincoln Sea: DMI, MET.NO, AARI
- Barents, Kara, Laptev Seas – MET.NO, AARI
- Beaufort Sea – CIS, AARI
- Baltic Sea: FMI, BSH, AARI
- Great Lakes: CIS, NIC

The NIC produces ice charts encompassing the globe and that overlap every other Service's area of interest. It could potentially share imagery with any of the other Services. Additionally, some Ice Services provide global support to national research ships. This provides some additional overlap where data costs could be shared on a more ad-hoc, infrequent basis.

### WHAT ICE INFORMATION IS EXTRACTED FROM SATELLITE IMAGERY?

Of the nine Sea Ice Services (excluding IIP) that responded to the questionnaire:

- All extract ice concentration from satellite images
- Six also extract Stage of Development
- Six also extract Floe Size
- Two noted ice edge, fractures, leads and polynyas as distinct from ice concentration
- One also extracts ice thickness and deformation
- One also identifies the fast ice boundary

Five of the sea ice services as well as the IIP responded that they obtain iceberg information from satellite images (IIP notes that they do not use imagery directly but have iceberg locations extracted for them by a third party). Where numbers of icebergs are relatively low, actual locations are



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obtained. Where there are large numbers of icebergs, areas of “few” or “many” icebergs are delineated.

### DO CURRENT IMAGERY SOURCES MEET REQUIREMENTS?

#### SYNTHETIC APERTURE RADAR

Most Ice Services indicated that Radarsat-1 and ASAR have sufficient resolution and coverage to meet their needs. The most difficult problem for most Services is that it is too expensive. Some Ice Services noted that they would use more SAR imagery if it were financially possible. There are also problems associated with long lead times to order imagery and competition for imaging time from other users (not necessarily other Ice Services). One Service noted a problem with irregularity of reception. Classification of sea ice was noted as a problem by several Ice Services citing difficulties in rough seas, detecting very scattered ice, and the need for regular sequential imagery, ancillary information and human interpretation expertise. Most Services would like to use more SAR imagery if it was available and affordable. At least one Service stated that they are investigating the use of new types of SAR data such as ALOS.

#### VISIBLE / INFRARED

Most Services (except IIP) cited AVHRR as being very useful but with barely sufficient resolution. MODIS was categorized as being better except that it suffers from longer term-around times. These sensors are greatly impacted by cloud cover and darkness.

#### OTHER

A few respondents noted that it is difficult to determine ice thickness from satellite data and indicated a need for new types of sensors (satellite or otherwise) to fill this gap. However, one Ice Service stated that they obtain ice thickness from SAR imagery.



## SECTION 2: IMAGERY

This section was intended to obtain information about specific imagery requirements and usage to determine whether it is feasible to negotiate a more attractive bulk discount for imagery from the different suppliers by implementing agreements between the Ice Services. It is notable that the National Ice Center uses more imagery than all of the other respondents put together. Table 1 summarizes the results.

### DATA FUSION OF MULTIPLE IMAGERY SOURCES

Eight of the ten respondents indicated a need to use multiple image sources in order to adequately analyze ice conditions. VIS/IR and SAR imagery were most often mentioned.

### COORDINATE SYSTEMS, PROJECTIONS AND DATUMS

Of the eight respondents who addressed this issue, all but one use a single coordinate system for their products – four use Polar Stereographic, two use Lambert Conformal Conic and two use Mercator map projections. One Service provides products in both Polar Stereographic and Lambert Conformal Conic. All eight Services reported using WGS84 datum as their single datum.

TABLE 1: TYPES AND QUANTITIES OF IMAGERY USED

Imagery	# Services Using	Total # Images Per Month		Average # Images Per Month		Cost per Image
		incl NIC	excl NIC	incl NIC	excl NIC	
NOAA AVHRR	9	10900	2050	1211	256	\$0-8
NOAA QuikSCAT	4	152	90	38	30	\$0
NOAA GOES	1	540	0	540	0	\$0
NASA MODIS	8	993	625	124	89	\$0
NASA AMSR-E	3	122	60	41	30	\$0
JMA MTSAT	1	300	300	300	300	\$0
CSA RADARSAT-1*	7	805	505	115	84	Approx \$150-\$4000**
ESA ENVISAT ASAR	7	235	185	34	31	Approx \$0-\$800**
ESA ERS-2	1	300	0	300	0	\$0
ESA ENVISAT GMM	2	122	2	61	2	\$0
DMSP SSM/I	6	390	150	65	30	\$0
DMSP OLS	1	1140	0	1140	0	\$0
JAXA ALOS	1	300	0	0	0	\$150
<b>TOTALS</b>		<b>16299</b>	<b>3967</b>	<b>3968</b>	<b>853</b>	

\* Includes MDA RADARSAT-2 from one respondent

\*\* Lower costs reflect bulk quantity purchase agreements or project-specific discounts



## SECTION 3: PROCESSING

The questions in this section were designed to explore the type of licensing agreements for commercial imagery that could be needed.

### LEVEL OF IMAGERY PURCHASED

Of the eight Services that purchase commercial imagery, one reported that it uses Level 1A (radiometric corrected imagery) while the others all stated that they use Level 1B - geometric corrected imagery.

### IMAGE PROCESSING

Eight of the nine Services using imagery said they do some processing of the images prior to use. (The IIP has its images processed by a third party.) All eight re-project the images to their internal map projections. Three Services indicated that they average SAR data to reduce data volume and radar speckle.

All of the Services using imagery indicated that they manually analyze it for ice conditions. One stated that it does automatic ice thickness classification. Most stated a use of image enhancement techniques including band combinations and filters for edge detection, contrast enhancement, etc. One Service indicated the use of cloud mask and surface temperature thematic products to facilitate ice analysis. In some cases, these enhancements are applied by analysts manually while in other cases they are applied automatically. There is a requirement by most Ice Services to perform contrast stretches (8-bit to 16 bit) on image data.

### VALUE ADDED PRODUCTS CREATED FROM IMAGERY

All of the respondents using imagery indicated that their primary products are ice charts or written reports that do not contain any image pixels. One Ice Service stated that they produce an ice thickness product created automatically from imagery but that does not contain image pixels. One respondent indicated that they distribute low resolution images to icebreakers while another distributes images to icebreakers in their original resolution. One respondent creates annotated images from original imagery that are distributed as .jpg or .gif files. One respondent creates a product showing vector drift of ice features based on time sequential images. This product can retain original image pixels but, for public distribution, only the ice drift vectors are displayed and not the image pixels. Two Services stated that they do create a product obtained by combining imagery from 2 or more sensors.

A question about access to Value-Added Products (VAP) of the original imagery was intended to determine whether Ice Services need the actual imagery itself or whether some VAP produced by the imagery supplier would be sufficient. Five respondents addressed this question and all indicated some interest in VAPs but not to the exclusion of original imagery. Four expressed the opinion that VAPs currently produced automatically from satellite images do not capture the same information as actual imagery. Failure to meet resolution and timeliness requirements was specifically mentioned as a difficulty.



## SECTION 4: PRODUCTS

This section was intended to provide an understanding of the products supplied to the end user.

### PRIMARY END-USER PRODUCTS

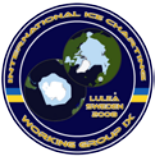
The following table is a concatenation of the input provided by the respondents. Not all Ice Services produce all of these products. Where answers were similar, they have been combined.

TABLE 2: END USER PRODUCTS

Feature	How Extracted / Identified	Format	End Use
Sea Ice Charts	GIS ice chart containing polygons in which the ice parameters (concentration, stage of development, floe size) are approximately homogeneous. Each polygon is described by the WMO Egg code, the Baltic Sea ice code or other national code. The distribution and concentration of sea ice are identified from satellite, aircraft and ships.	.jpg, .gif, .pdf, .html  Shapefiles, .e00 (ArcGIS)  Paper form distributed electronically (fax, web, NAVTEX, etc.)  Intranet to icebreakers  Some Services are in the process of introducing S-57 format	On board ships to aid navigational decisions  On board and ashore for voyage planning by shipping, fishing, etc.  By harbours and by government authorities to establish recommended routes and for strategic planning  Scientists and for climatology  Input to weather, ocean and ice numerical models
Ice Thickness Charts	Ice thickness extracted automatically from satellite images	.gif  Intranet to icebreakers	As above
Ice Drift	Vector drift arrows extracted automatically from satellite images	.gif	As above
Ice Forecasts	Forecasts of future ice conditions (concentration, thickness, floe size, drift, pressure, leads)	.gif  Text  Intranet to	As above



		icebreakers	
Ice Edge	Ice edge positions extracted from ice charts	Text	Onboard ship for navigation decisions
Icebergs	<p>Individual iceberg targets identified from satellite, aircraft or ship are recorded in a GIS database or in text messages.</p> <p>Some products indicate the number of icebergs in each latitude/longitude degree square. Others include iceberg information on ice charts using WMO-symbology for “berg water”. Products may indicate “few” or “many” icebergs or concentrations of icebergs.</p> <p>The limit of all icebergs may be shown as a vector line.</p>	<p>.gif, .pdf</p> <p>.e00 (ArcGIS)</p> <p>shapefiles</p> <p>SIGRID codes</p> <p>Paper chart</p> <p>Text</p>	<p>Onboard ship for navigation decisions</p> <p>Input to database of iceberg positions used by local ice management contractor on offshore oil rig</p>
Limit of All Known Ice (LAKI)	Determined manually by IIP personnel. LAKI is based on the estimated positions of icebergs that have been drifted using a computer model.	<p>Graphic HF radio-fax chart</p> <p>Same information also provided in a text format</p>	Transatlantic ships desiring to avoid any encounter with an iceberg
Sea ice – satellite images (as permitted by license)	Satellite images with coastline/latlon grid or other overlays to enhance various features and reduced in size to decrease volume; occasionally have annotations added to identify ice features	<p>.jpg, .gif, .pdf, .png</p> <p>Images contain fused imagery and automatically or hand-drawn graphics/labels</p>	<p>On board ship to aid navigation decisions and in Coast Guard traffic control centres to establish recommended ice routes.</p> <p>Also in company head offices, federal and regional emergency centres for navigation and risk mitigation decisions.</p>
Sea ice edge	Ice edge positions extracted	Text and shape files	Distributed via email or NAVTEX to



	from ice charts		vessels and for science and climatology
Fractures, Leads and Polynyas	Location, orientation and size extracted from satellite images	.jpg, .gif Text	On board ship to aid navigation decisions

**ADDITIONAL INFORMATION THAT ICE SERVICES WOULD LIKE TO MAKE AVAILABLE**

The most frequently cited new information requirement is for ice thickness – either from remote sensing or ground observation. Related information on ice ridging or topography and ice strength was also mentioned by more than one respondent.

The next more frequently listed new product requirement is the ability for provide satellite SAR images to end users, rather than just ice charts.

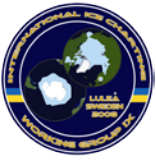
Single responses noted a need for progress in remote sensing of sea ice of concentration of less than one tenth, more detailed iceberg position data, more robust estimates of total concentrations and stages of ice development during the summer melt season and better detection for new, very thin ice or brash ice.

The BAS indicated that users generally would like higher resolution imagery/charts and ice forecasts from an integrated model, ideally on a seasonal as well as weekly basis, as an aid to route planning.

**TABLE 3: DISTRIBUTION METHODS**

Distribution Method	Number of Respondents using this Method
Website	10
E-mail	9
Marine RadioFax Broadcast	6
NAVTEX	3
ftp download	6
Telefax (Facsimile)	4
CD / DVD	1

The BAS notes that, in general, the ship captains that they support prefer information to be sent to them by e-mail, rather than having to search the Internet, even when there is a good web portal.



## SECTION 5: STANDARDS

This section was intended to determine the standards that are currently in use to provide an indication of the level of difficulty to be encountered to implement collaborative data sharing in a distributed system of multiple organizations.

### GEOSPATIAL DATA STANDARDS

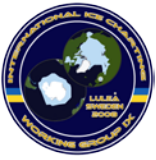
Two respondents neglected to complete this section. Two of the other eight respondents indicated that they do not currently employ any geospatial standards.

Of the remainder:

- Four use ArcGIS standards
- One uses a proprietary geospatial format based on TIFF; but also provides products in the ESRI shapefile format
- Five provide products in SGRID-3 format
- All use raster formats including .gif, .jpeg, .png and .pdf.
- Four respondents noted use of GEOTIFF
- One indicated that they use bzip2 for distribution of compressed products
- Two respondents noted that implementation of S-57 is in progress
- One respondent is in the process of developing a web map server

### USE OF METADATA FOR PRODUCTS

Only three respondents specifically indicated that they provide metadata. One cited the FGDC-STD-012-2002 content standard for digital geospatial metadata while the other uses a customized format that is conformant with FGDC. However, it should be noted that the SGRID-3 format implicitly includes this metadata standard and that five of the respondents previously stated that they provide products in SGRID-3 format. Another respondent indicated that they are in the process of entering metadata into a national geospatial database which contains metadata.



## SECTION 6: SOFTWARE

This section attempted to understand the software that is used to carry out ice analysis to indicate the level of difficulty to be encountered in achieving interoperability.

### SOFTWARE CURRENTLY USED TO PROCESS / ANALYSE IMAGERY

Of the eight respondents who use software to process and analyze imagery, three stated that they use customized systems based on ESRI ArcGIS. Three others indicated ArcGIS without mentioning customization while a fourth uses ESRI ArcView. One Ice Service identified IceMap as their analysis software. One Service noted TerraScan and tools from the Alaska SAR Facility while another indicated it uses ENVI.

Other software listed by respondents includes Windows Paint, FORTRAN, PWWAVE (PV-WAVE?), C, C++, Visual Basic, FWTools and ESA BEST/BEAM.

The respondents noted use to varying degrees of proprietary software in combination with Commercial Off-The-Shelf software.



## SECTION 7: DATA STORAGE

This section tried to determine if, how and where data should be made available online or as an archive, including mechanisms for data access between the Ice Services. The questions were intended to inform a potential architecture and requirements for a catalogue for data discovery and access.

### DO YOU NEED TO EXCHANGE/SHARE DERIVED PRODUCTS WITH OTHER ICE SERVICES?

One respondent neglected to answer the questions in this section. Of the others, all but one indicated a need to share products with one or more external Ice Services.

### DO YOU NEED TO SHARE HISTORIC DATA FROM AN ARCHIVE?

One respondent indicated a regular need to share historical data with another Ice Service. Three respondents indicated that they occasionally need to share historical data. The remainder have no requirements to do so.

### DO YOU NEED TO DISCOVER DATA HELD BY OTHER ICE SERVICES?

All of the Ice Services noted a requirement or a desire to occasionally search for data from other Ice Services, mostly for special projects.

### DO YOU STORE YOUR DATA IN A SPATIAL DATABASE MANAGEMENT SYSTEM?

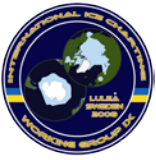
Two respondents neglected to answer these questions. Of those that did answer, two do not have data in a DBMS, four keep their spatial data in ESRI ArcGIS 9.1, one uses ArcView but is migrating to ESRI ArcGIS 9.2 and one indicated that part of the data is held in ArcGIS and Oracle but that there is process underway to develop a national geospatial data infrastructure. One provides specific products in a spatially enabled database to a national archive centre.

## METADATA AVAILABILITY

None of the respondents stated that they have metadata available for all of their data holdings although one respondent is planning to develop an automatic metadata capture capability. There is some metadata available for limited data sets.

### DO YOU NEED TO RETAIN ORIGINAL IMAGERY?

None of the respondents indicated a specific requirement to retain imagery indefinitely. Most of them keep imagery on-line for varying periods of time (from several days to months) to have fast access. Beyond that, off-site storage of imagery would be acceptable to the Ice Services with some caveats on speed of access.



## SECTION 8: END USERS

This section was intended to determine whether there is a requirement from end users for products that would provide some capability for digital manipulation.

### DO YOUR USERS WANT THE ABILITY TO DIGITALLY MANIPULATE YOUR PRODUCTS?

Two of the respondents identified users who need capabilities to overlay products or switch between multiple images, products or vector datasets at the present time. However, three other Ice Services noted that they believe that such a requirement will arise in the future.

The ability to view ice information products via a web-based browser application was noted by three respondents as suiting the needs of some users. One of these is developing such an application. It was not seen to be a significant priority by the other Ice Services. There is some interest for land-based clients but the major users are at sea where Internet browsing is deemed too expensive to be practical – the Baltic Sea being an exception.

In speculating about the kind of functionality that users would like to have in future, a couple of respondents indicated that it would be useful for users to be able to import ice information directly into their own systems – such as for vessel route planning. In this vein, Electronic Navigation Chart software was specifically mentioned. However, it was also noted that significant scientific work on better forecast products is necessary to make this optimal.



## CONCLUSIONS

- Acquiring and analyzing satellite imagery is a major activity for every Ice Service, with the exception of the International Ice Patrol. Ice Services use hundreds to thousands of images every month, largely extracting the same ice information from the imagery. The volume of imagery used corresponds closely to the size of a Service's area of interest.
- Routine monitoring of the area of interest accounts for the greatest quantity of imagery used requiring regular repeat coverage of the area of interest. Real-time support to navigation uses about half as much imagery although, depending on the size of the area of interest, routine monitoring also serves navigation. The distinction can be made that real-time support to navigation implies non-repeat coverage that follows shipping activity in the vicinity of ice.
- There is considerable overlap in the areas of interest of the Ice Services and therefore considerable opportunity for Services to share imagery or image analyses.
- All Ice Services (except IIP) use visible/infrared imagery and most use synthetic aperture radar imagery. The major deficiencies in meeting requirements are:
  - Cloud cover for VIR imagery
  - High cost of SAR imagery along with lengthy advance ordering time and competition for imaging time
  - Difficulty in determining ice thickness from any satellite imagery
- There is considerable similarity among the Ice Services in terms of the types of processing they do and the ways in which they process satellite imagery. However, there is little standardization among Ice Services for processing.
- None of the Ice Services are willing to relinquish satellite imagery in favour of pre-processed value-added products.
- The range of ice information products available from Ice Services appears to meet users' needs with the exception of ice thickness (although one Ice Service does produce ice thickness charts) and information on topography and ice strength.
- The ability to provide satellite SAR imagery to end users is desired by some Services, but is not a universal demand.
- Websites and e-mail have overtaken facsimile and NAVTEX as the primary means of distribution of ice information products by Ice Services.
- The use of geospatial data standards is not universal among Ice Services although there is considerable overlap in the types of standards employed. This is also true of the types of software that Ice Services use. While ESRI-based systems are most common, not all Services use this software.
- Although all Ice Services express a need to share products and data with other Ice Services, it does not appear to be a driving requirement for the Ice Services but rather an occasional nice-to-have.



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## INTERNATIONAL ICE CHARTING WORKING GROUP

While this questionnaire survey was not exhaustive, it does reveal some interesting characteristics of the ice charting community. While most members of the community engage in substantially similar work and produce comparable products in many overlapping areas, there is relatively little collaboration among the Ice Services. The Services have paid considerable attention to standardizing products for their international user community but much less so to standardizing the processes by which the products are created. The reasons for this are varied and are perhaps the basis for another, more-focused questionnaire.

John Falkingham  
IICWG Secretariat