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Integrated Weather, Sea Ice and Ocean Service System (IWICOS)

Baseline System Report

IWICOS Report No. 2

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Contents

Executive Summary

The overall objective of IWICOS is to develop a prototype marine information system that will provide a single-entry access to integrated meteorological, sea ice and oceanographic (met-ice-ocean) products in electronic form, and to demonstrate this prototype for a group of users working in fisheries, sea transport, exploitation of marine resources in Northern European waters, or whose work is related to sea ice monitoring on a scientific or pre-operational basis.

This report describes the status of the IWICOS baseline system, which is the first version of the system, as developed after 18 months of the project. The background for the development of the baseline system is the user requirement analysis and the system design study (IWICOS report no. 1, 2000) which was the major effort in the first six months of the project.

The design study established the need for three major subsystems in the IWICOS processing chain: production, brokering and presentation. The production subsystem will be responsible for all processing required to generate the defined products using various types of remote sensing, in situ and model data as input and incorporating a suite of tools ranging from simple, automated algorithms to complex computational or human-computer interaction software. The production subsystem will also hold a repository of all generated products and make these available to the broker subsystem or directly to thin/thick clients, which implement the presentation subsystem for selected end-user groups.

Products in this project mean met-ice-ocean data at various processing levels ranging from initial data sets (meteorological observations and forecasts, satellite data, ice data, etc.) to client products which are based on various presentation methods to bring essential information to the customers (text, images, graphical products, etc.). Initial products are a set of met-ice-ocean data sets which are available among the partners and used to develop various methods for combination and presentation of the data sets in user-friendly ways. These presentations are defined to be the client products, and they are dependent on the client capability to transfer, display and manipulate with the data sets.

The main task of the broker is to establish contact between the producers and users of met-ice-ocean products. Several broker interaction models were investigated to find the most suitable solution for the IWICOS prototype. It was found that a hybrid of the basic-service-model and the diminished-broker will best serve the needs for both thin and thick clients, which are needed by different user groups. In the basic-service-model, a broker will receive a request from a (thick) client, use its internal metadata repository to find the closest supplier and collect all needed data from a number of production systems, distributed across countries and networks. Then, it will bundle these data for optimal transfer rates and send the bundled data to its client. This is suitable for connections via a low-bandwidth communication network, such as cellular phones and satellite communication. In the diminished-broker model, the broker will also receive requests from its (thin) client, but instead of obtaining and passing on all products to the client, it will simply provide a reference to them. Then it will be the client's responsibility to connect to the relevant production system using the provided references and to retrieve the desired products by means of standard protocols such as HTTP or FTP. This type of distribution mechanism is suitable for high-bandwidth networks, which are typically land based.

Several types of presentation systems are foreseen for different user groups in IWICOS. The systems can be classified into three groups: 1) Thick clients with sophisticated manipulation and customisation capabilities, which will download products for further processing, analysis and display; 2) thin clients, which will download products that have already been prepared for display (ready-made client products), and which therefore will need only limited facilities for further processing; and 3) balanced clients which is a combination of thin and thick clients. The flexibility in the defined 3-tiered system architecture and the hybrid brokering models, will enable development of tailored end-user systems (thin/thick/balanced clients) for different areas and user groups - within a common framework of shared services for product storage and dissemination.

A key issue in this first phase of IWICOS has been to define a common format, to enable exchange of products between the different suppliers in the consortium and the thin/thick clients to be developed. The IWICOS format has to capture both metadata (i.e. description of the data) and data (i.e. measured, estimated and predicted environmental parameters), and must be extensible to support new product types that are planned for the second demonstration period. A major effort has been to

define and implement the metadata standard and the broker which allow interoperability between different service providers and customers who wants to retrieve different products.

The metadata specification was developed by DMI, DTU and VTT based on the input provided by all partners. This specification has been developed by means of XML and XML Schema, both W3C standards. Metadata documents and example files have been distributed to all partners through the internal web site, enabling a detailed review of the specifications and check of compatibility with all baseline products. DMI have prepared the final metadata specification for the baseline system, rigorously documenting each metadata element and the relationship between them. The IWICOS data formats have been defined to be BSQ, GRIB, Shapefile and XML. With XML both representation and presentation of data sets is more flexible. This allows a structure to be defined for the textual products and XML-related technologies such as XSLT (XSL - eXtensible Stylesheet Language, XSLT - XSL Tranformations) can be used to transform the data set to HTML that can be displayed directly in a web browser.

Another key element of the IWICOS system is the broker, currently denoted the baseline broker, and the software packages needed to use it. The broker is based on public domain software (web and servlet server from Apache, SOAP, Xerces, etc.) and uses standard HTTP for communication between the broker and the other system components (Producer Server and Facade). Documentation of the broker and links to software have been made available to all partners who have started to test it.

Based on the provided metadata search criteria, the broker will return an XML document, either a summary of matching fields for the query or the full metadata specification for the data sets satisfying the criteria. This enables flexibility in the way the broker can be used. Low bandwidth connections can request the matching fields mode, which will require small amounts of data to be sent between the system modules. High bandwidth connections can use the full metadata option since they are less concerned with the amount of data being transferred.

A Java applet is used to test the interface to the broker, and a command line scripts is set up to insert. the metadata for a new product into the broker database Also a script for retrieving the list of products delivered by a specific data-producer is produced. These test stubs and scripts are made available for the partners at VTT's broker web site.

All partners are using the metadata specification, the data formats and the broker when they build up their data provision services and products which are tailored for various types of users (i.e. thick and thin clients)

The Baseline system currently demonstrates the metadata insertion functionality of the Broker, and the full functionality of the Service chain will be demonstrated in the Extended system. The variety of clients is dictated by the variety of requirements posed by both the different user groups and geographical areas, but the philosophy is that the data itself will be interoperable between the various client implementations. In the Baseline system implementations the user requirements are ascertained and feedback gathered for the Extended system. The following clients are developed in the project:

- A forecasting service for weather and waves in Icelandic waters (thin client)
- Wave forecasting and water level service in the Baltic Sea (thick client)
- The Met-ice-Ocean Viewer for product integration in Greenland waters (thick client)
- SAR ice image and derived products for the Arctic (balanced client)
- Java web browser for SSM/I and other met-ice-ocean data for all regions (Balanced client)

These clients will be further developed in the next phase of the project as the main elements of the Extended system. The Java web browser at DTU/DCRS have already been extensively tested and is used operationally. The first test of the Met-ice-Ocean Viewer has been carried out in Greenland. All the clients will be demonstrated and assessed by users during year 3.

The response from the consortium to the report first review meeting, held in Brussels 30.01.01, where three independent reviewers evaluated the project after one year, is attached in Appendix B.

1. Introduction

1.1 User groups and their requirements

The background and motivation for the IWICOS project is the general requirement from a wide range of users of met-ice-ocean data to have easier access to services and data provided by meteorological offices, ice information centres and oceanographical institutes. This means that monitoring and forecasting products in digital format should become easily available on Internet and that marine communication systems should be used to send text, images and graphical products to users at sea. Ship captains have expressed a clear requirement to have more integrated information available on the bridge. Ideally, all information should be accessible in digital form via one system, which is easy to operate and avoid to use many different computer systems onboard a ship.

In previous sea ice projects, user requirements for ice information have been identified for different regions and for the main users categories such as ice-going vessels, cargo vessels, fishing boats, oil companies, shipping companies, sea transport administrations, national ice and weather centres, research activities and other marine operations under rough conditions. The study refers to the main results from these projects covering the Baltic Sea, Greenland waters and the Northern Sea Route. These requirements have been supplemented by results from a dedicated user investigation in Iceland and the Design Workshop where invited users stated their opinion on how the IWICOS prototype should be developed.

The requirements for sea ice information are closely related to meteorological and oceanographical parameters. For example, the temporal changes in the ice conditions are always driven by atmospheric forces (winds, air temperature) or ocean forces (currents, waves, tides, ocean temperature). This means that ice data should in principle be accompanied by atmospheric and ocean data which govern the behaviour of sea ice. The requirements are related to products and their quality, time-space coverage, methods of delivery, timeliness, regularity and costs. There are different products which cover various spatial and temporal scales, for example short-term and long-term weather forecasts, ice maps for strategic or tactical operations. The cost-benefit ratio is an important factor which determines which product or service a user selects in a given situation.

The meteorological information needed by users at sea can basicly be divided into three groups:

- Tactical information, consisting of observations (ground observations and satellite products), very-short-range forecasts (nowcasting, < 3 hours) and warnings, issued whenever needed.
- Strategic information where traditional weather forecasts, issued at least two times a day as text according to WMO standards (up to 24 hours) are the most important item. These forecasts might be supported by prognostic charts from numerical models but they should be enhanced in such a way that they are in agreement with the worded forecast.
- Planning information is mainly based on medium range weather forecasts (up to 10 days). Such forecasts may be presented as fields but forecasts beyond day 4 should preferably be expressed in probabilistic terms, based on EPS (Ensemble Prediction System).

1.2 Recommendations from the user requirement studies

- IWICOS should recognise that the marine user community may have different needs for information, may work in different regions and have different educational background.

- The IWICOS system must be able to combine information from different sources in a flexible way. Consequently, it should be possible to construct user defined displays and combinations of information.

- IWICOS should provide an integrated system enabling users to access and display all information with one system. It is important that users do not have to worry about sources of a given information layer and formats . Today, much of the information already exists, but must be collected from different sources and may exist in different forms that obstruct easy combination of information layers from different sources.

- It is important that the IWICOS system has a user friendly interface so difficulties with understanding and using the system will not obstruct the application and dissemination of the system. Therefore the user interface must be developed by means of known industry standards or public domain tools.

- IWICOS should aim at adopting existing standards for data presentation, e.g. standard colour coding of ice charts and standard symbols for presentation of meteorological information and ensure source independence and seamless display of data from different sources.

- IWICOS must disseminate products using standard technologies and standard data exchange formats.

- IWICOS must acknowledge the limitations of marine communication systems and the cost of using them and must adopt methods to effectively handle these problems.

- IWICOS should provide a range of products with different levels of information, aimed at different user groups. In both demonstration periods a representative set of free products should be prepared and advertised through the IWICOS web site, to raise awareness of the service and allow for a wide audience to give feedback on the products and IWICOS prototypes developed.

- The cost of the met-ice-ocean products is another important aspect in the end-users' evaluation of IWICOS. Some products will require high-priced input data and/or a significant amount of processing and therefore be expensive to generate, while others may be produced by means of low-cost input data and simple, automated processing tools. Whether or not a product is to be delivered in near real-time will also have a large impact on its cost. As information needs will differ between various user groups, and also depend on the type of activity carried out, the user should be able to select and change the level of service requested to best match the current situation.

1.3 From initial data products to client products

Products in this context means both met-ice-ocean data at various processing levels ranging from initial data sets (meteorological observations and forecasts, satellite data, ice data, etc.) to client products which are based on various presentation methods to bring essential information to the customers (text, images, graphical products, etc.). In this project we define initial products to be a set of met-ice-ocean data sets which are available among the partners and used to develop various methods for combination and presentation of the data sets in user-friendly ways (Fig. 1.1). These presentations are defined to be the client products, and they are dependent on the client capability to transfer, display and manipulate with the data sets.

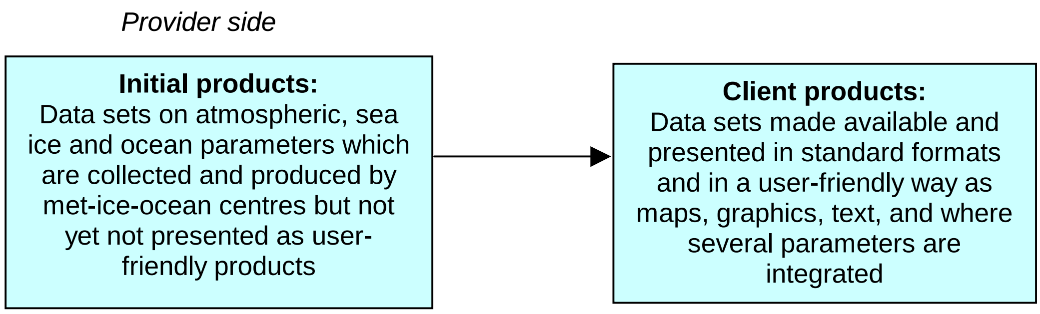


Figure 1.1 Definition of initial products and client products. Client products can either be produced by a central server on the provider side and be downloaded for display the user's PC, or they can be produced locally after downloading initial products from a central server. The latter option makes it

possible for the user to carry out own operations on the data and make his own client products provided that he has necessary software for such operations.

The partners have selected and developed a set of initial and client products for the IWICOS baseline system. In these products data from several sources are integrated and presented, and in some cases meteorological, oceanographical or sea ice data are combined and displayed on top of each other using GIS. The client products must be tailored to the geographical regions, the communication limitations and the specific user requirements in these regions, while other products will be more or less similar in all regions. For example, wind fields and air temperature can be used together with ice data, showing the dynamics of the ice fields. Use of GIS technology is an important element in the integration of several data types. Ice kinematics algorithms can be improved by including wind forcing, and ice type classification can be made more reliable if the time series of ice data from the preceding days and weeks are made available. The products can be divided into the following main groups:

- Near-real time products which are used for monitoring and are available on regular basis (hourly, daily, weekly, etc.)
- Forecasts of weather, ocean and ice conditions which may be supported by output from numerical prediction models,
- Archived products giving statistical information about mean and extreme conditions as well as snapshots of interesting events, and
- Experimental products

An example of archived products is a set of several thousand SAR quick look images of Arctic sea ice available from a database, which give many examples of detailed ice images in different parts of the Arctic. Other archived products are ice charts, AVHRR and SSM/I data and meteorological statistics. Improvements in operational ice monitoring is expected by the introduction of SAR images and ice classification from SAR images, providing better resolution in the ice maps. During IWICOS the digital GIS information about ice properties in the routine ice chart will be combined with SAR image classification algorithm. Daily and archived SSM/I ice maps, combined with AVHRR, SAR and other data products, are developed for presentation on Internet. Ice drift and wave forecast visualisations are developed in the Baltic Sea and in Icelandic waters.

Improved visualisation of the data is under testing in all study regions, Access to the products will be possible in several ways. In the Baltic Sea, products are sent out to icebreakers and some ships using communication satellites and cellular telephone system. In Icelandic and other waters ice and weather information is sent to fishing vessels by a special developed information system, the MaxSea system, which communicates via Inmarsat.

In general, the products are developed to serve two different user types: the “active” users who need to have a **thick client** in order to download different types of data for own processing and presentation; and the “passive” users who work with a **thin client** which is sufficient for a user only wants readymade products which can easily be downloaded without further processing. A combination of the two types of clients, called **balanced client**, is also developed where the user has some limited possibilities to carry out operations on the products, but without the full software package which a thick client will need.

1.4 IWICOS architecture

The logical architecture for IWICOS (and most dynamic multiproducer GIS-systems) can be divided into three subsystems as shown in Fig. 1.2.

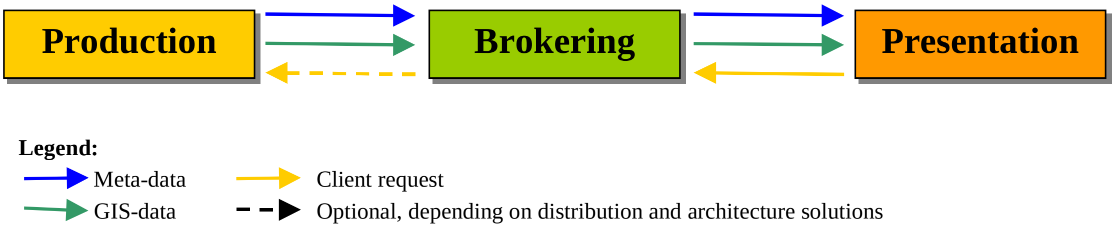


Figure 1.2 The reference architecture for IWICOS.

The main subsystems include the ***production*, *brokering***, and ***presentation*** of GIS-products. The actual tasks in these subsystems are determined by decisions related to issues such as distribution, delivery mechanisms (push/pull) and client model (thin/thick). In the production subsystem the GIS-data is produced and packed for delivery with a meta-data description of the product. The brokering subsystem receives this information (or plain meta-data and GIS-data address) and the user needs (either a profile or a request).

Communication with other servers for locating and collecting data is also possible if the distribution solution supports this. Presenting the GIS-products provides the user a view of the products and means for selecting them. In the *thick-client* model the products can be customised and new user defined views created.

It is clear that many choices over technologies and solutions that are to be used have to be defined at the architecture definition phase. In the following sections we will discuss these issues and present a few alternative approaches to the division of tasks and distribution in the architecture.

Production Subsystem

The Production subsystem produces the raw-data or refines it to useful products. Within the reference architecture we do not define whether or not the production should have a dedicated server, we simply identify that for IWICOS system such a functionality is essential. The need for a server is further dicussed below. Closely related to the need of a server is the question of data-storage, it must be decided whether the data is stored in production subsystem, or brokering subsystem, or in both of them. Anyhow, to begin with at least the meta-data has to be passed on from the production.

Brokering

The main task for the Broker is to establish contact between Clients and Producers. This can occur in many forms wich are discussed on following sections. The storage issue above concerns also the Broker. It can be argued that a Broker is not needed at all. However, if a Broker is used, it should be responsible for locating other Brokers and Producers in addition to meta-data (and product-data) brokering. Thus, if no Broker is used, other means of locating services should be applied.

Presentation

The task for the client software is to present the data to the user. There are, however, two approaches to this task. The first one, called *thin-client* approach, is just to provide ready-made presentations of the data. The other one is the *thick-client* approach which may include complicated processing of the data to gain a presentation that is customized for that particular user. Both thin and *thick-client*s should be supported, due to the heterogenity of IWICOS users. Lately this division to *thick*- and *thin-client* systems has become a bit ambiquous, due to the Java-applet clients which have both *thick*- and *thin-client* properties. Based on this trend we define a *thick-client* to be a client that requires a separate installation process to be accomplished on the target computer before the client can be used.

Service chain illustration

The flow of data from the providers to customers forms a service chain which will supply both thin clients and thick clients (Fig. 1.3). The initial data products are transformed into client products through different processing in production and brokering servers, and client software. In this chain, the data that the user needs, are produced, processed for delivery, selected and presented to the user in the form of client products. The base for identifying the useful data and the varying processing it requires, is the meta-data that describes the attributes of the actual data, such as its location, time, nature and origin. Extensible Markup Language (XML), XML Schema and Resource Definition Framework (RDF) provide a good base for the definition of the meta-data presentation (Karttunen 1999, Lassila 1999). The main components in the service chain are the subsystems of the reference architecture described above. However, these subsystems consist of smaller separate processes to be described in Chapter 4. After each processing the data is shifted to the next phase, in these interfaces the data should preferrably be presented using open industry standard formats (if possible). In the service chain both client types can be served, by providing the data for client software on different levels of processing. In a *thick-client* the final processing of data is done by the client software and in *thin-client* this is done by the broker server. Thus *thick-client*s receive a kind of 'bulk-data' and *thin-client*s receive final products.

The use of the open industry standard formats in data transfers forms natural connection points for additional processing that may be applied on some data. Such processing will actually widen the service chain concept to a *service graph*. All data is not necessarily treated similarily and value added services can be provided by externalized service producers that apply some specific processing on the data that is not usually available in the basic service.

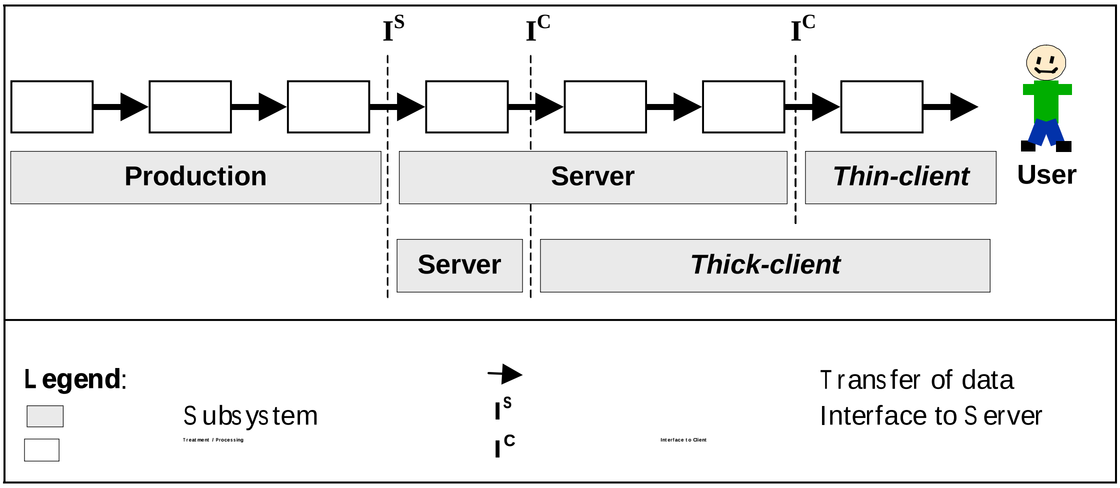


Figure 1.3 The service chain for Client-Server GIS-systems.

2. The partner's role and contribution

The synergy between the partners can be described in terms of their different expertise, product development and the different geographical regions in which they work. The main contributions from the partners so far are:

- **DTU/DCRS:** Daily ice concentration fields from SSM/I for specific regions as well as for the whole Arctic and Antarctica. In addition weather forecasts from NCEP are downloaded and prepared for access via DCRS' Internet browser. Additional weather forecasts can be delivered from DMI as needed by all partners. DTU/DCRS develops integrated products by combination of SSM/I and NCEP/DMI wind as well as other satellite data for distribution via their Internet browser (thin client). DTU/DCRS' primary role is, as research and development institution, to lead the development of the Java-based Internet service, which the other partners are using.

- **DMI:** producer of sea ice charts in the Greenland Sea based on NOAA AVHRR and RADARSAT SAR images. SSM/I data are used as supplementary information. Provider of weather forecasts for the Greenland areas as well as other areas as required by other partners. DMI develops integrated weather and ice chart product for the Greenland area based on a thick client solution. DMI has operational responsibility and delivers various products to users in the Greenland area.

- **IMO**: Provider of weather forecasts, waves and sea ice charts based on observations in the areas around Iceland. Textual information is provided in Icelandic and English. These products will also be used by DTU/ DCRS' Java-based service. IMO also uses the products delivered by DTU/DCRS and DMI in areas where IMO has responsibility for operational service. IMO works closely together with RADIOMIDUM in the distribution of products to end users.

- **RADIOMIDUM (subcontractor)** is a company which specialised on delivering information packages in digital form to fishing vessels. The company has developed a streamlined system called MaxSea which includes an end user system onboard vessels and communication with a database on land where weather forecasts and other met-ice-ocean products are stored.

- **FIMR:** provider of ice and ocean services in the Baltic Sea: ice charts in the winter season, sea surface temperature, water level data, wave data and forecasts. FIMR receives weather forecasts and other atmospheric information from Finnish Meteorological Institute and use this information as input to the ice and ocean services. FIMR develops new met-ice-ocean products for the Baltic Sea in close cooperation with VTT.

- **VTT**: research institution which develops end user systems, communication solutions and new products which are used by FIMR and other operational services in the Baltic Sea. VTT has a key role in design of the IWICOS architecture and developing the common IWICOS modules which all partners are using.

- **NERSC:** research institution which develops various marine SAR application products, including a pilot system for SAR ice monitoring in the Arctic. The NERSC baseline products include SAR image quicklooks, with derived parameters (e.g. interpretation, classification and ice motion). NERSC uses DTU's and DMI's products for the Arctic as a supplement to the SAR products.

All the data products come from a relatively small number of initial data products (some types of satellite data, meteorological fields, wave fields and other fields from atmospheric and ocean models). The number of products becomes higher because there are different standards and techniques for presenting the data. For example an ice chart for Greenland waters is presented in a different way than an ice chart in the Baltic Sea because the are different standards and agreements. Therefore several client products can be different, technically, whereas the information content can be similar. In IWICOS, we only need relatively few products (both initial and clent products) to demonstrate the prototype system we are developing. On the other hand, with agreed standards for products and their metadata, it is easy to incorporate many different types of client products based on the same initial data sets. One of the objectives of IWICOS is to allow a wide range of client products to be accessible via the clients which constitute the end user systems.

3. The IWICOS Metadata Standard

3.1 Background

A metadata standard (IMS-001-2001) has been developed specifically for the IWICOS project. Several existing standards have been investigated and tested including the comprehensive ‘Standard for Digital Geospatial Metadata’ (FDGC-STD-001-1998) established by the Federal Geographic data Committee (FDGC, 2000). However, none of the existing standards fully match the IWICOS product assemblage. The varied nature of IWICOS products combined with the fact that many of the investigated existing standards consist of superfluous components when considering the IWICOS requirements urged the development of an IWICOS specific standard. Although the majority of components in the IMS-001-2001 has been specifically designed for IWICOS products some generic components have been adapted from the FDGC-STD-001-1998 and implemented in the IMS-001-2001 structure. Establishing an IWICOS specific standard at the same time adds a flexibility to the IWICOS, meaning that the standard continuously can be adapted and extended to IWICOS products.

3.2 Methods

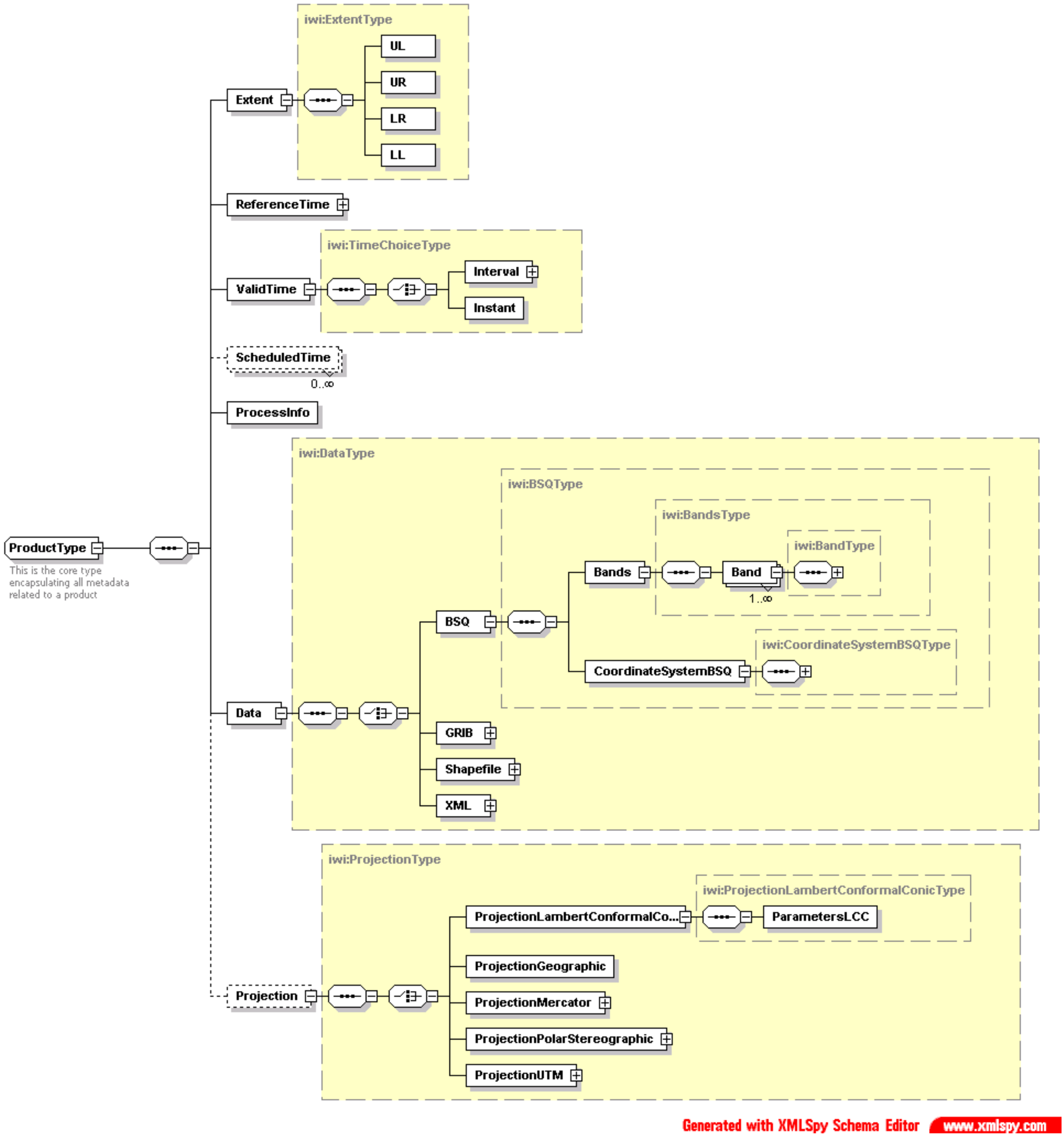
The development of IMS-001-2001 has been carried out by means of XML and XML Schema in accordance with W3C recommendations (see W3C Recommendations 2000 a, b, c and d). The metadata definition itself consist of XML Schemas and the metadata files are XML documents instantiated from these schemas. The XML Schema definition consists of 17 schema files connected through common namespace declarations. The division into separate schema files are made as a database-like division into themes in order to simplify the development environment and ease revision/updating. Once the core structure of the schema definition has been established the maintenance of the IMS-001-2001 is not laborious. The implementation of new products/parameters, units, projections etc. is quite easily accomplished. Thus, the IMS-001-2001 has been continuously updated and extended to match IWICOS product requirements. All metadata XML documents are validated against the schema definition prior to release. This ensures that metadata files are IWICOS standard compliant and can be exchanged and understood by product servers, Broker and end-user systems.

3.3 Content Model

The schema definition is build around a core element named ‘Product’. From this core element a tree structure emerges consisting of child elements in an element-on-element structure with each element being associated with a set of attributes. Part of the content model for the schema definition is shown in Fig 3.1.

As can be observed from Fig. 3.1 the IMS-001-2001 consists of 7 generic child elements connected to the core element ‘Product’. A short description of each generic element follows:

- **Extent:** Defines the bounding geographical coordinates of the product
- **Reference Time:** Especially used for numerical prediction products where it defines the time of analysis
- **Valid Time:** Especially used for numerical prediction products defining the valid time (analysis + prognosis)
- **Scheduled Time:** Defines the time for next similar product
- **ProcessInfo:** Comprises information concerning data origin, quality and producer information
- **Data:** Comprises the actual data information for the four IWICOS exchange formats
- **Projection:** Defines the data projection - a set of 5 frequently used projections have been implemented



Name	Type	Use	Value
Availability	xsd:boolean	required	
FileLocator	iwi:LocatorType	required	
FileSizeInBytes	xsd:nonNegativeInteger	required	
Compression	iwi:CompressionType	optional	

Figure 3.1: Part of the IWICOS Schema Definition content model. In the upper part of the diagram the core element 'Product' are shown together with a set of child elements. As an example are shown, in the lower part of the diagram (the table), the attributes related the element 'Data'.

3.4 A metadata administration tool

The IWICOS Adminstration tool (IwicosAdmin) is a graphical frontend to the baseline Broker at VTT in Finland. IwicosAdmin enables the data producer to easily transfer IWICOS metadata files to the Broker. In addition, it is possible to check which metadata files have already been submitted, and to view selected metadata files in a standard web browser. With an XML-compliant browser this presentation will use the defined style sheets at the DMI server, providing a nicely formatted display of the metadata.

Figure 3.2 shows the IwicosAdmin tool used to inspect IWICOS metadata files located at NERSC. The first file has just been transferred to the Broker, and is thus included both in the local list (left part of user interface) and in the Broker list (to the right). IwicosAdmin also enables viewing of metadata descriptions for products submitted by other partners, when the operator has chosen to retrieve the metadata list from that particular partner or from "All" partners as shown in Fig 3.2.

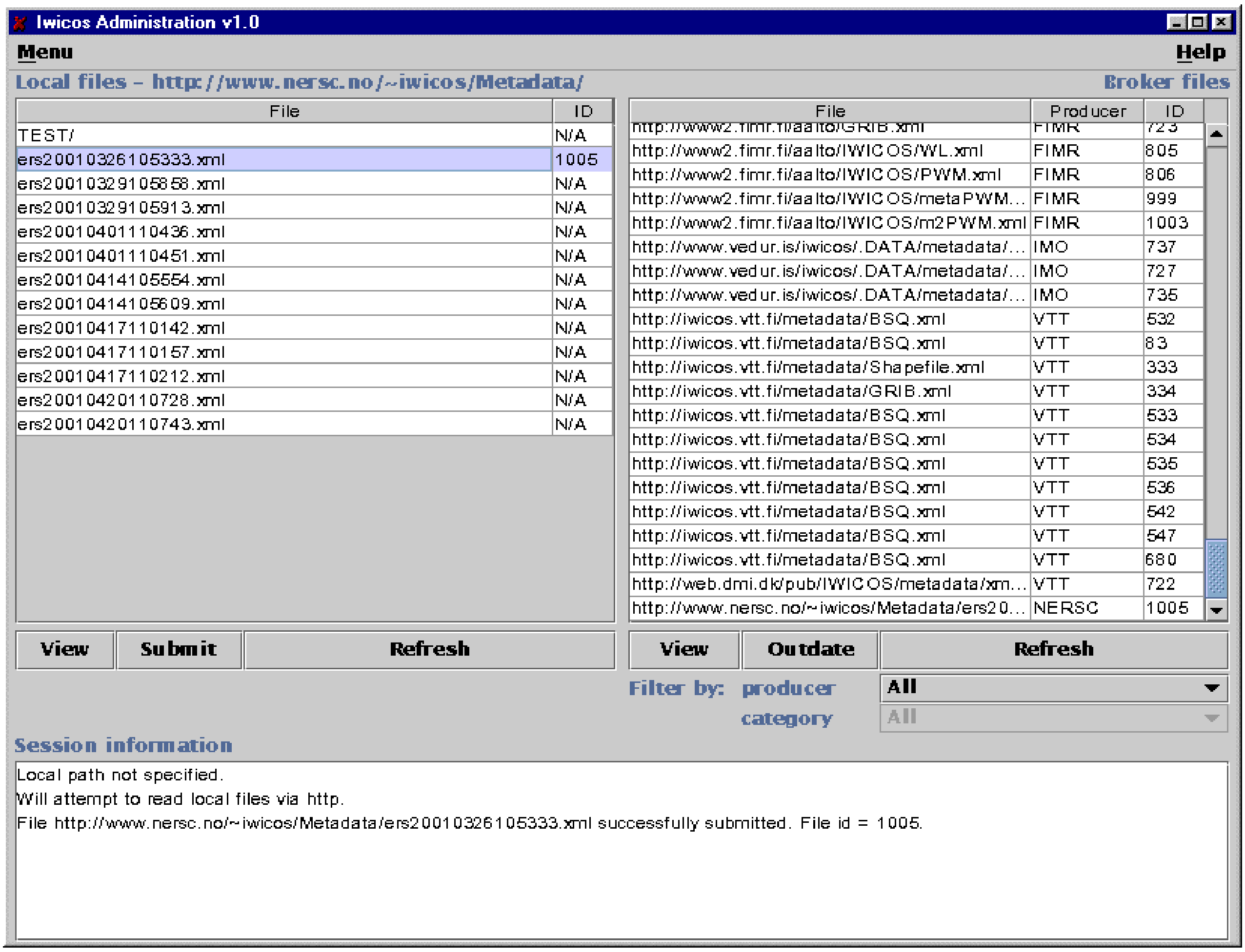


Figure 3.2: User interface of the Iwicos Administration tool.

4. Interoperability, Communication and Client Capabilities

4.1 Interoperability

The IWICOS interoperability is based on a common description of available products and their features presented in XML. These metadata descriptions are submitted to the Broker. The customers can base their product selection on the metadata description, and then retrieve the actual products from the Producer Servers with the help of a Facade subsystem. Finally Client Software is used to acquire a presentation of the product data (Fig. 4.1).
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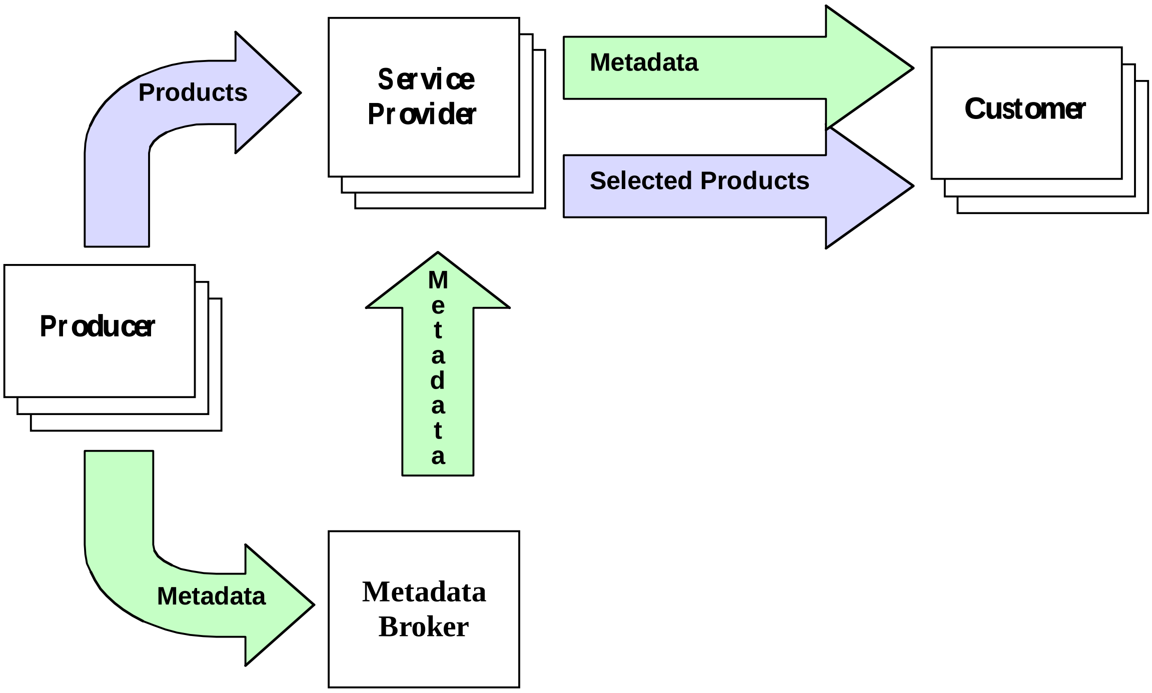


Figure 4.1 The IWICOS Service Chain.

4.2 Architecture

The Producer Server integrates the IWICOS system to the producer's existing production process. It communicates with the Broker using specific small stub programs designed for the messaging between these components.

The Producer Server consists of two parts (Fig. 4.2):

a. An active part, that informs the Broker of the events, such as a new product becoming available or an old product getting outdated, that occur in the production process.
b. A passive part, that is basically a web server where the active part places it's output for the Broker (the metadata) and the Facades (the product data) to retrieve.

The set of data formats for the communication between the Producer Servers and the Facades was limited to Binary Sequential Files (BSQ), GRIB (GRIdded Binary), Shapefile, and XML for reducing the complexity of the implementation. Within the End-User Systems (Facade and Client Software pair) there is no such limitations. The Facades can use the base types listed above to generate products in any format. Basically the End-User System is a black box - the subsystems outside should and shall not be interested in what happens there.

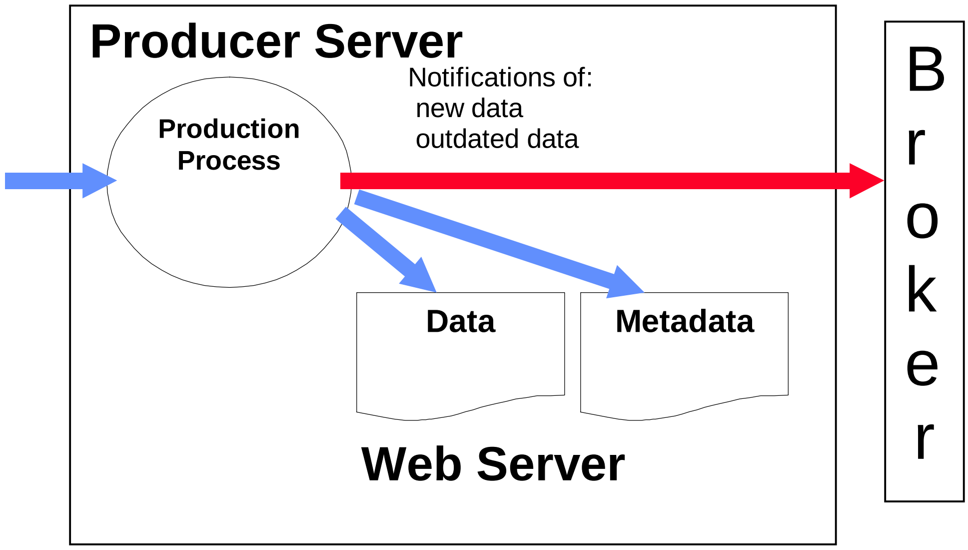


Figure 4.2. The IWICOS Producer Server Components and Internal Data Flow.

The Broker provides two interfaces for metadata operations. One is intended for the Producer Servers for managing the Broker's metadata content. The other one is the query interface for the End-User Systems through which they can access the Broker's metadata content. The Broker is based on freely available elements, Apache Tomcat web-server, Apache SOAP 2.0 implementation, MySQL database, and Linux OS (RedHat). The service programs are written in Java.

The Broker is divided into three main components: the Database, a storage for metadata; the Metadata Parser, that will process the metadata descriptions of the new products and store them to DB for later access by queries; and the Query Engine that will interpret the queries posed in an XML format to SQL and execute them on the DB and return the results for the caller. (see Fig. 4.3).

The Broker communication is implemented with the Remote Procedure Calls (RPC) implemented over the Simple Object Access Protocol (SOAP). The RPC uses a small program called a *stub* in both ends of the communication, that will marshal the required parameters and return values of the call. Example of stubs is shown in Fig. 4.4.

The Facade implementations can vary a lot. For a simple web-browser based client it will be closely integrated to the Client Software and it is hard to say where one begins and the other one ends. On the other hand it may be very complicated element containing reasoning of user needs based on a profile, product generation based on the products provided by the Producer Servers, and filtering of unnecessary components of products (e.g. layers with unnecessary data content).

The Client Software is intended for presenting the acquired data and the implementations have a range from thin to thick clients. All types of clients (thin, balanced and thick) will probably be tested in the demonstrations during the project.

The IWICOS Architecture is illustrated by the four following communication scenarios between the various subsystems: **Producer Server - Broker, Facade - Broker, Facade - Producer Server, and Facade - Client Software**. These are explained in more detail below.

Producer Server - Broker
In this scenario the Producer Server manages the Broker metadata content with the following operations: *newProduct*, *outdatedProduct*, and *productList*. The operations are used for informing the Broker of new and outdated products, and acquiring of a list of the producer's products that have metadata stored to Broker.

Facade - Broker
In this scenario the Facades execute queries on metadata at the Broker to gain a list of products that might be applicable for user needs. This interface contains a single operation called *query*. However, it

is more complicated than the previous scenario hence the parameter and reply contents is more dynamic. We will get back on this issue in Section 5.3 describing the Broker implementation for the Baltic Sea.

Facade - Producer Server
In this scenario the Facades acquire the actual product data based on the metadata retrieved in the previous scenario. The product data at the passive (web-server) part of the Producer Server is accessed using the HTTP-protocol and thus is not very complicated to implement.

Facade - Client Software
This scenario is actually a black-box one - the decision of what protocols and other means of communications to use here is left for the designer of the Client Software - Facade pair. In the scope of the IWICOS System it is enough for us to know that such implementation is present.

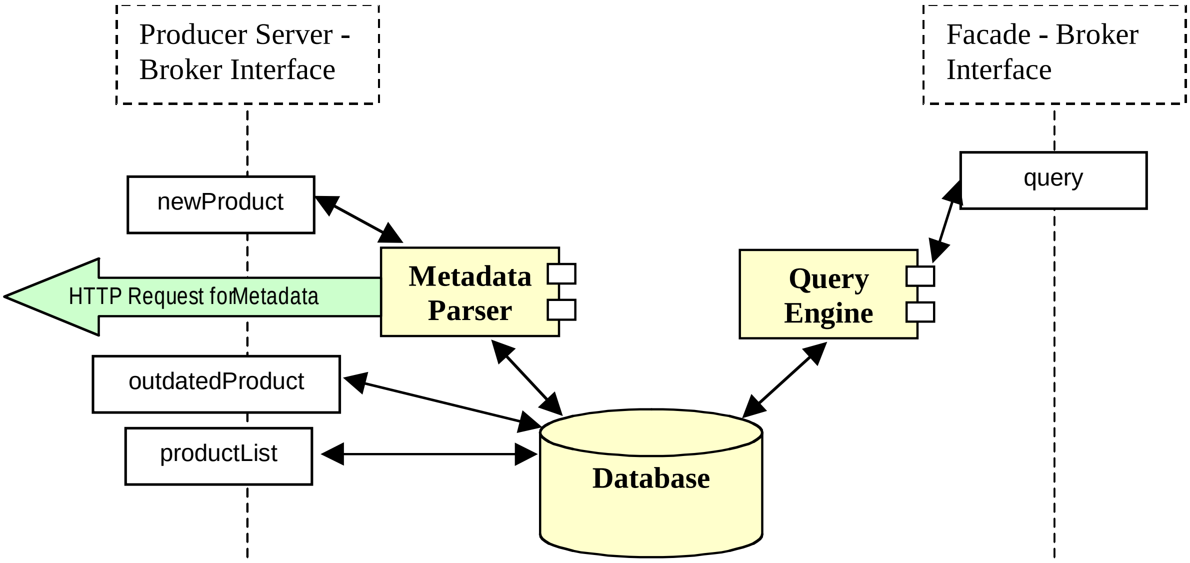


Figure 4.3: The Broker Internal Structure.

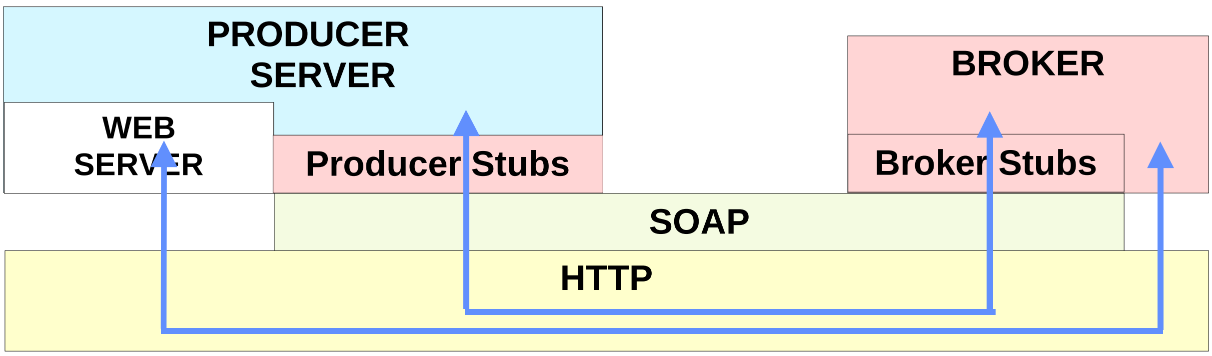


Figure 4.4. Stub Example - The IWICOS Producer Server and Broker Stubs.

4.3 Communication Possibilities

Basically the requirements for IWICOS communication capabilities fall in to two categories. First category is the communication between the Producer Server, Broker, and Facade components that will occur in a stable high-band Internet environment. The second category is the communication within the End-User System (Client Software and Facade). This category is more complicated since the means and capability of the communication may vary a lot. The parties may communicate with a high-band internet connection (a web-client), a costly high-band satellite connection, or narrow-band radio or cellular phone connection. A summary of different shore-ship communication possibilities is given in Section 4.4

The first scenario is under a rapid change, although the communication capability is likely to remain at approximately the same level, but the way of using this capability is changing. New Internet technologies are developed with an aim to solve the problem of describing, discovering, selecting, and using the various services automatically. This trend known as the Semantic Web or Web Services is evolving rapidly.

In the second scenario there will not likely be any dramatic changes in the near future. The Satellite connections are likely to remain expensive and thus scarce. The cellular phone network coverage will be limited and out of scope for the sailors at high seas, although the GPRS and other new technologies may improve the bandwidth.

Considering these categories/scenarios our natural conclusion is to concentrate on the first category, with a preparational view for the future technologies. Our approach to implementing a interoperable metadata services introduces the use of SOAP, SOAP RPC and extensive use of other XML related technologies where applicable (see Figure 4.5). The SOAP was selected to be the basis for our implementation after we had already designed the system architecture - virtually the architecture would been quite the same even if we had known this in advance.

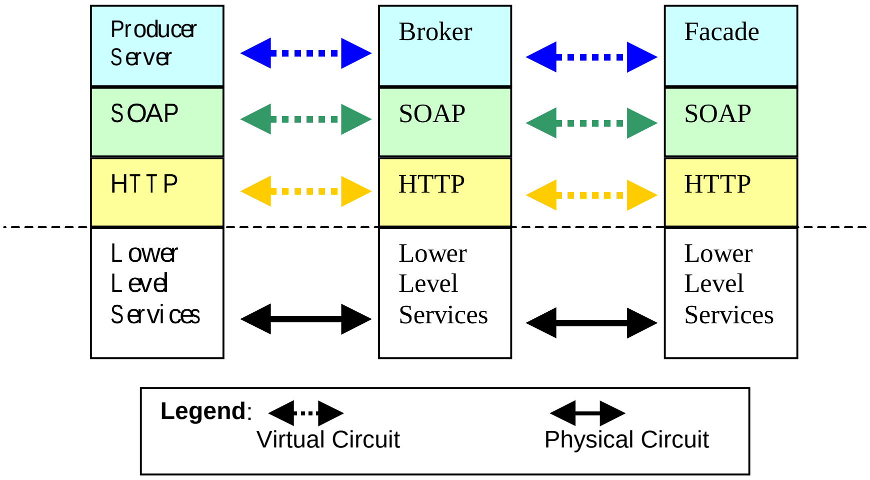


Figure 4.5 The SOAP Based Communication in the Broker Interfaces

The Simple Object Access Protocol (SOAP) is an open standard that supports the interoperability of autonomous systems. Since it can be run over the Hypertext Transfer Protocol (HTTP), it helps to resolve the communication problems that occur when the applications have to operate through the firewalls of different organizations. Furthermore, SOAP supports RPC for invoking services on the service. SOAP messages can contain data packed in XML format, so they provide an ideal platform for implementing a tailored messaging service. Due to the XML approach the SOAP messages are easy to understand when compared to their binary correspondents such as CORBA, DCOM and RMI. The character-based nature of the messages introduces the requirement for encoding and decoding at the ends of communication, however this is relatively easy task when compared to the cost of the transmission itself. The SOAP is also a fundamental building block in the yet to come Semantic Web technologies, that will probably utterly change the way we look at implementation of interoperability.

4.4 Shore - Ship Communication limitations

To update the information regarding the capabilities at sea, a Questionnaire was sent to selected potential users in the Baltic Sea and for users in the Greenland Sea. The purpose was to recheck the capabilities that the potential users at sea have at the moment and also to have a forecast of the situation two years from now on. In the Baltic sea the target group are shipping companies that have cargo or passenger ships navigating in the Baltic Sea all year around. As the Baltic sea is relatively small, many ships find it sufficient only to use terrestrial communication means such as GSM. Still, satellite communications is increasing. The questionnaire was brief on purpose and aimed at providing basic information on what telecommunication equipment ship have on-board and what kind of communication program is used. The reason for this is that potential IWICOS customers hardly want to purchase any special equipment just to get the services provided by IWICOS, or this kind of requirement would severely restrict the number of potential IWICOS users.

The questionnaire indicates that E-mail is used on almost all ships at the moment, and is estimated to be used 100% within two years. All ships in the shipping companies interrogated, have GSM-data, but GSM data is limited to use when the ship is within reach of the base station (maximum of 30 km approximately from the nearest base station because of delay restrictions). Although this may seem to be a severe restriction, for ships whose route is mainly in the Baltic sea , the time when out of reach will be about 10 hours, and for the passenger ferries regularly navigating in this area. even less than this. When looking at the answers from the Greenland Sea the situation is quite different. In this area the ships are out of reach of the cellular phone system 95% of the time, thus the need for satellite communications is much higher here.

The Icelandic survey, the results of which is presented in Table 7.1, shows that satellite traffic is expected to triple within the next two years. In the Baltic area NMT-450 service will phase out (support for NMT-450 will cease in Finland by the end of 2002). The role of the TETRA system at sea is still unclear.

High speed satellite links at sea are still not common, but in the Baltic Sea within 2 years of time a third of the ships in the shipping companies that replied to the questionnaire, will have a high speed link, either on permanent or on-demand basis. This will enable use of more detailed images and maps for a larger user group at sea.

The questionnaire and the answers are given in Appendix A.

4.4.1 Relevant satellite communication possibilities

As indicated in the questionnaire, there are users that are out of reach of the cellular phone network 95% of the time. If HF-communications are left out, satellite communications are the only possibility. This section will take a closer look on some of the alternatives.

Satellite systems can be divided based on the orbiting height of the satellites. Geostationary satellites are positioned at a height of 35,786 km above the surface of the earth, thus being positioned at a fixed position in the sky relative to the surface of the earth. In principle three satellites can cover the earth up to a latitude of about 70ºN, although users like Royal Arctic Shipping Line have reported successful communications up to 76ºN. The long distance to the satellite causes a round trip signal delay of about 0.5 s, which affects interactive communication possibilities.

Medium earth orbit height satellites have an orbit height of about 10.000 km and LEO (Low Earth Orbit) satellites have a height of only 1.000 km. Less height causes less coverage per satellite, thus a LEO system with full-time coverage must consist of many satellites (IRIDIUM consists of 66 satellites)

4.4.2 INMARSAT-systems

The INMARSAT satellites are geostationary. The most important INMARSAT systems are:

INMARSAT-A is the original INMARSAT analogue system. Using a modem, the system can offer a data rate of up to 9.6 kbit/s. INMARSAT-A is widely used on around 18000 ships of all types [FOR00].

INMARSAT- B is the digital successor of INMARSAT-A. Data communication speed is 9.6 kbit/s and up to 64 kbit/s if the High Speed Data service is used.

INMARSAT -C is a low cost data transfer service operating at 600 b/s. The user is charged by volume of data instead of connection time. INMARSAT-C can be used for sending messages up to 32 kbytes in length. The terminal is small and weighs only 3-4 kg.

INMARSAT Mini-M is capable of data communications of 2.4 kbit/s. The maritime version of the antenna is gyro-stabilized. The cost of a call is about $2.70 per minute.

As a rule of thumb [FOR00], when looking at the suitability of the different INMARSAT systems, the following guidelines are given for regular file transfer needs:

- For total message sixe less than 250 bytes: Inmarsat-C messaging service
- For file sizes 250 to 4 kbytes: Inmarsat Mini-M
- For file sizes 4 to 40 kbytes: Inmarsat-B 9.6 kbit/s
- For file sizes above 40 kbytes: Inmarsat -B HSD (64 kbit/s)

4.4.3 VSAT-systems

Very Small Aperture Terminal (refers to the antenna pointing accuracy needed) systems are used for providing a fixed communication channel from ship to shore and vice versa either by using a dedicated satellite receiving station at the center or by using a gateway provided by the operator. VSAT systems are suitable for applications where large volumes of data need to be transmitted at regular intervals or continuously. On-board a 1,2 m stabilized antenna is needed.

For ships on the move in different geographical areas, it may be necessary to contract several service providers, as no company is offering global coverage.

It is estimated that for VSAT to be a viable option, users need to be on Inmarsat-B HSD for over one hour a day (depends on contract length, size of fleet etc.)

VSAT systems are used by the new Finnish multipurpose icebreakers and by some passenger ferry lines in the Baltic Sea.

4.4.4 EMSAT

The EMSAT system has a coverage that is well suited for operation in the North Atlantic region (Fig. 4.6). Emsat is a mobile communications system from Eutelsat, providing high quality voice, fax and data communications, as well as features for SMS, position reporting and monitoring applications. EMSAT uses the EMS payload on Italsat F-2 at 16.4 East. EMS was developed by ESA (European Space Agency) to provide new- generation mobile services in L-band. The payload is managed by Telespazio (Italy). Typical per minute charges are US$1.20 - $2.00. Data transfer rate is 4.8 kbit/s.

4.4.5 LEO-systems

The main systems that are based on LEO satellites, and operate in the North Atlantic region are Iridium and Globalstar. For messaging applications the Orbcomm system is a possibility.

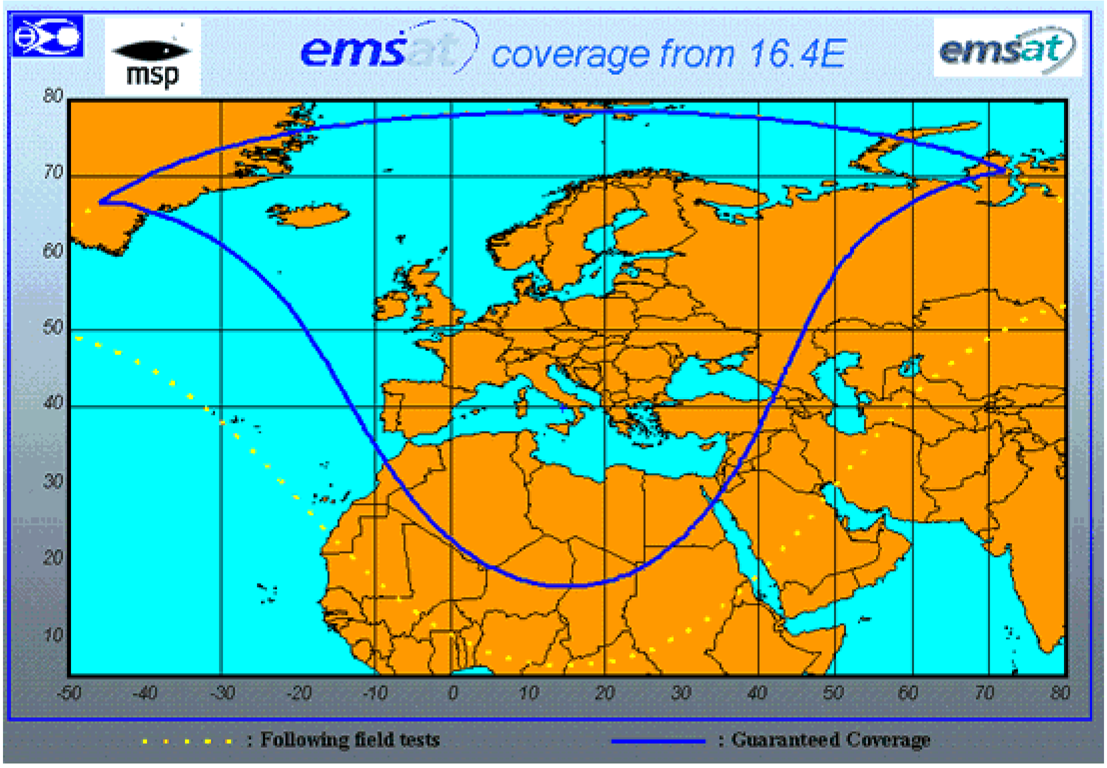


Figure 4.6 Coverage map for the EMSAT system

Globalstar consists of 48 satellites and provides a data transfer rate of 9.6 kbit/s. For IWICOS users the main limitation is the maximum latitude of 70ºN. This is the limit for continuous operation. When going further north the service is not available all the time and at a latitude of 78N, the connection is possible to establish only 10 - 15%of the time. Thus Globalstar resembles INMARSAT with respect to the coverage. In Scandinavia the terminal and service provider is GNE (Globalstar Northern Europe). The price for the equipment is around US$ 2.200 and the cost for calls is 1.8 - 2.2 □ per minute.

The **Iridium** constellation consists of 66 operational satellites and seven spares orbiting in a constellation of six polar planes. This gives a full coverage of the earth.

Iridium was already almost buried, when, in December 2000, Iridium Satellite LLC acquired the operating assets of Iridium LLC including the satellite constellation, the terrestrial network, Iridium real property and intellectual capital. The new company Iridium Satellite LLC has essentially no debt and claim that the monthly operating charges are one-tenth the cost of the previous Iridium. Through its own gateway in Hawaii, the U.S. Department of Defense relies on Iridium for global communications capabilities. The DoD contract should guarantee a long-term customer base.

The data communication capability of Iridium is 2.4 kbit/s . This puts practical size limits to a file to be transmitted. The cost for calls are $0.50 to $1.50 per minute (Iridium to Iridium or iridium to PSTN line), and a maritime grade phone costs about US $3.000 .

Orbcomm has 48 satellites, plus 8 spares, in low earth orbit. The network is data-only and uses packet switching technology. Orbcomm is intended for relatively short messages - if the satellite is not in contact with a Gateway Earth Station (GES), the messages (called GlobalGrams) are stored in the satellite until it passes over next GES - thus Orbcomm cannot be the only data transfer system if the amount of data to be transferred is in the order of 100 kbytes and more.

A Standard GlobalGram is composed when an ORBCOMM satellite is in sight of both the terminal and GES. The message can contain up to 2000 characters. A Standard GlobalGram is delivered near "real time". As more GESs become operational, standard messages can be sent and received throughout the world.

A Store-and-Forward GlobalGram is composed when the satellite is in sight of the terminal but not the GES. A Store-and-Forward GlobalGram can contain up to 200 characters (about). The message is stored in the satellite and delivered when a GES is in view. Each user terminal can theoretically have up to 16 globalgrams stored on each satellite, thus posing a limit on the information to be sent. This limit is also reflected in the pricing - some sources claim a price of up to US $ 6/kbyte which would make the use of ORBCOMM very expensive for larger amounts of data.

Orbcomm have been suffering financial difficulties, and last year (Sept 2000) filed for 'Chapter 11' bankruptcy protection. The outstanding debts are believed to stem largely from the system rollout phase, with net running costs being of much smaller concern. Industry opinion is that Orbcomm will prevail, largely because of the commitment of many third-party equipment and system manufacturers to the success of the system, and evidence of increasing service take-up by a diverse range of customers.

4.5 Client Capabilities

Client Software visualizes the weather and ocean information to the user. It retrieves the data from Façade, which has already tailored the data into a proper form (Fig.4.7)

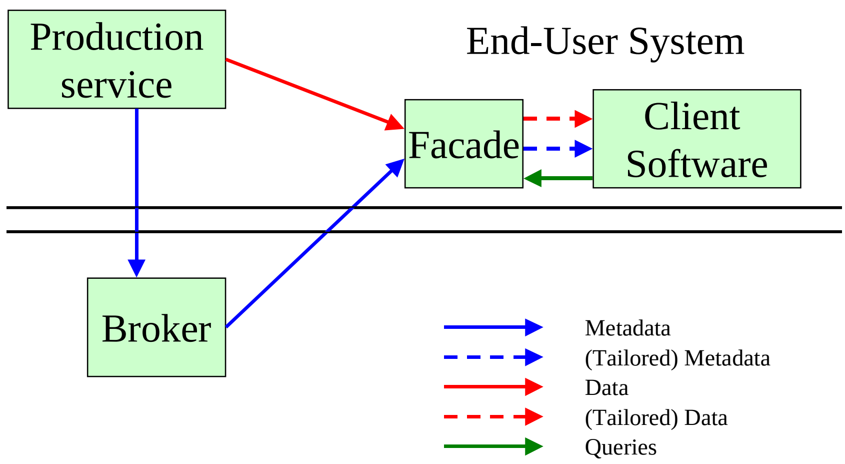


Figure 4.7 The data flows between Client Software and Façade.

Façade can be understood as a server for the Client Software. Façade and Client Software may not be located in the same physical location, and the communication link between Client and Façade varies from high-speed Internet connection to low band width cellular phone link.

Client Software includes the following functions:

A Receive/Retrieve data from Facade
Client Software has to be able to communicate with Façade. User queries are delivered to Façade, and meta data and weather-ocean data are received in return.

B. Display meta data
Client Software is responsible for presenting the meta data to the user and providing means for product selection. Predefined profiles may also be used to retrieve the purposeful data. In that case, some means for profile input are provided.

C Generate presentation (thick-clients)
As thin clients mainly present the image data received from the server as such, thick clients are able to generate a visualization from raw data received.

D Allow customisation of the presentation (thick-clients)
Users typically want to combine some data and filter out some aspects of data. (E.g. User may want to see weather forecast and an ice-image combined on the screen, or want to view only the wind field instead of whole weather forecast).

Is the client thin or thick?

The users of the IWICOS system will have a variety of communication capabilities in use. There are several ways to distribute the load between server (Façade) and client in order to get the most out of the communication link's band width. One way is to give all computational tasks to a *heavy server* and let a *thin client* only take care of the presentation. This *thin client model* needs a broad bandwidth connection as all the images are created on server side and delivered to the client.

The other way around is to have a *light server* delivering raw data to a *thick client*, which produces the images needed for presentation. The communication line is burdened only when the raw data files are transmitted to the client.

The third solution is the balanced model where a *semi-heavy server* performs all the demanding calculations and a *semi-thick client* takes care of the rest of the tasks. A Java-applet client can be considered as an example of the balanced model, as it may present ready-made images and generate customized views out of raw data.

Table 4.1 summarizes the different ways of distributing the tasks between client and server. The tasks include creating map images out of raw GIS data, creating overlay composite images, displaying the images, browsing the map (pan and zoom) and executing spatial queries (E.g. give me wind data for Baltic Sea area! What forecast data are available for tomorrow? Etc.). According to the table a thin client retrieves images and presents them as such on the screen. In the balanced model a client retrieves raster and/or vector data and draws images according to user's setting (zoom level, geographical viewport etc.). A thick client draws the images out of the raw data, which the server delivers to the client as such.

	Thin client	**Balanced**	**Thick client**
Façade/Server tasks	Map drawing Overlay drawing Map browsing Query	Query Map drawing Overlay drawing	File serving
Data transferred	Raster images	Raster / vector	Raw GIS data
Client tasks	Display	Display Map browsing Query input	Display Map drawing Overlay drawing Map browsing Query

Table 4.1. Possibilities to distribute the load between client and server.

5. Description of Baseline Products and Clients

5.1 Introduction to the Baseline System

The main purpose of the IWICOS baseline system is to demonstrate the advantages of being able to merge meteorological, ice and ocean data from a number of sources. Because of the very different communication capabilities of the different user groups, and the different needs for data, the concept will be demonstrated using a number of different end-user systems targeted at the different user needs/capabilities.

A key component of interoperability of the IWICOS system is the Broker. In the Baseline System the Broker has a preparational status, i.e. the metadata of the products is stored in the Broker, but no retrieval functionality is yet implemented. In the Baseline System interoperability of data on different platforms and by different users is demonstrated using a set of customized software clients from the following categories:

- *thick clients,*
- *thin clients and*
- *balanced clients*

The Baseline system currently demonstrates the metadata insertion functionality of the Broker, and the full functionality of the Service chain will be demonstrated in the Extended system. The variety of clients is dictated by the variety of requirements posed by both the different user groups and geographical areas, but the philosophy is that the data itself will be interoperable between the various client implementations. In the Baseline system some of the high-priority user requirements are implemented and feedback gathered for the Extended system.

The IWICOS baseline system consists of a number of products and clients which are developed according to the metadata standards, described in Chapter 3, and the architecture and client solutions, described in Chapter 4. Several thin and thick clients have been developed, which are summarized in Table 5.1 and will be described in more detail in this chapter.

Table 5.1. Overview of initial products and client products developed for the baseline system

Initial data products	**Client products**				
	Forecasts in Iceland	MIO Viewer Products for Greenland	Baltic Sea thick client examples	DTU/DCRS Web browser for all areas	SAR ice image data base for the Arctic
Atmospheric data Wind fields Pressure fields Temperature fields	Text forecasts	Display of atmospheric fields	Combined wind and wave maps	Atmospheric fields from NCEP	
Sea ice data Ice images from AVHRR Ice images from SAR Ice images from SSM/I Aerial surv. charts Ice reports from ships		Ice charts based on combination of several data sets	Ice charts based on SAR images	SSM/I ice charts Including archive of AVHRR images	Archive of SAR ice images from the Arctic and derived ice parameters
Ocean data Sea surface temperature Wave forecasting fields Sea level data Currents from models	Wave forecast map	Maps of SST and wave parameters	Sea level maps updated hourly		

5.2 Thin Client example and products from Icelandic waters

The baseline system at IMO contains 2 product chains, forecasts in plain text written by meteorologists and model output wave forecasts for Icelandic waters. Metadata for those products will be sent to the IWICOS Broker.

The target user group for IMO's baseline products will be fishermen on small boats. It is vital for them to receive detailed but still concise forecasts and warnings for their area. They will normally not have access to sophisticated communications systems onboard the boats and they will rely heavily on traditional communication, such as radio and telephone answering services. They will be able to approach graphical products on a specially designed web page which they can study before they leave home.

5.2.1 IMO's Product Chains

Text forecasts

Plain text forecasts are written for up to 17 areas. For the 9 areas close to the coast of Iceland they are issued 8 times a day but 3 times a day for the remote areas. They contain a description of the expected wind conditions together with cloud cover and/or precipitation. Strong gale warnings are issued if wind speed is expected to exceed 20 m/s. The forecast is stored in XML-format. Included in the XML-definition fields is also the maximum expected wind-speed in the forecast and information on eventual warnings.

Wave forecasts

The user survey reported in this document revealed much interest in wave forecasts. As a first attempt to fulfil this need numerical wave forecasts produced at ECMWF in UK and updated once a day will be included in the baseline system. They contain significant wave height, mean wave direction and mean wave period. They will be delivered to the baseline system in GRIB-format, one parameter and one forecast period in each file.

The production line of IMO's baseline products is shown in Fig. 5.1. The flow of metadata is indicated by dotted-line arrows but the flow of the products with solid-line arrows. Requests etc. are omitted from the diagram.

5.2.2 IMO's thin client

IMO will set up a website specially designed for small boat owners as they are the largest group of Icelandic seafarers. All IWICOS products that can be of use for this group will be available and will be presented in an accessible user friendly way.

Text forecasts

The XML-format for the text forecasts contains the maximal wind speed anticipated. This number will be used to draw a map where the users can get an overview of the expected wind speed in all Icelandic waters. The map is coloured according to the highest wind speed forecast in each area

If the users want to know more about some area they can just click on the area and a window will pop up with an eventual warning for the area, the weather situation and the weather forecast.

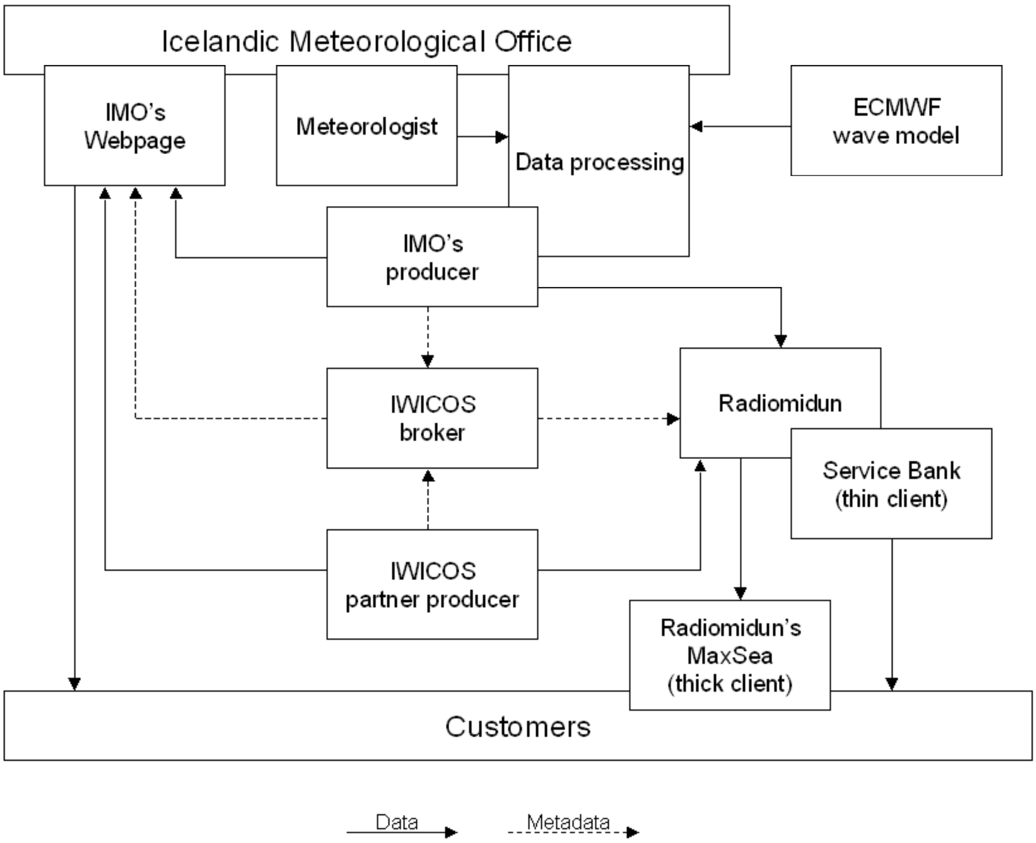


Figure 5.1 Data flow for IMO's baseline products

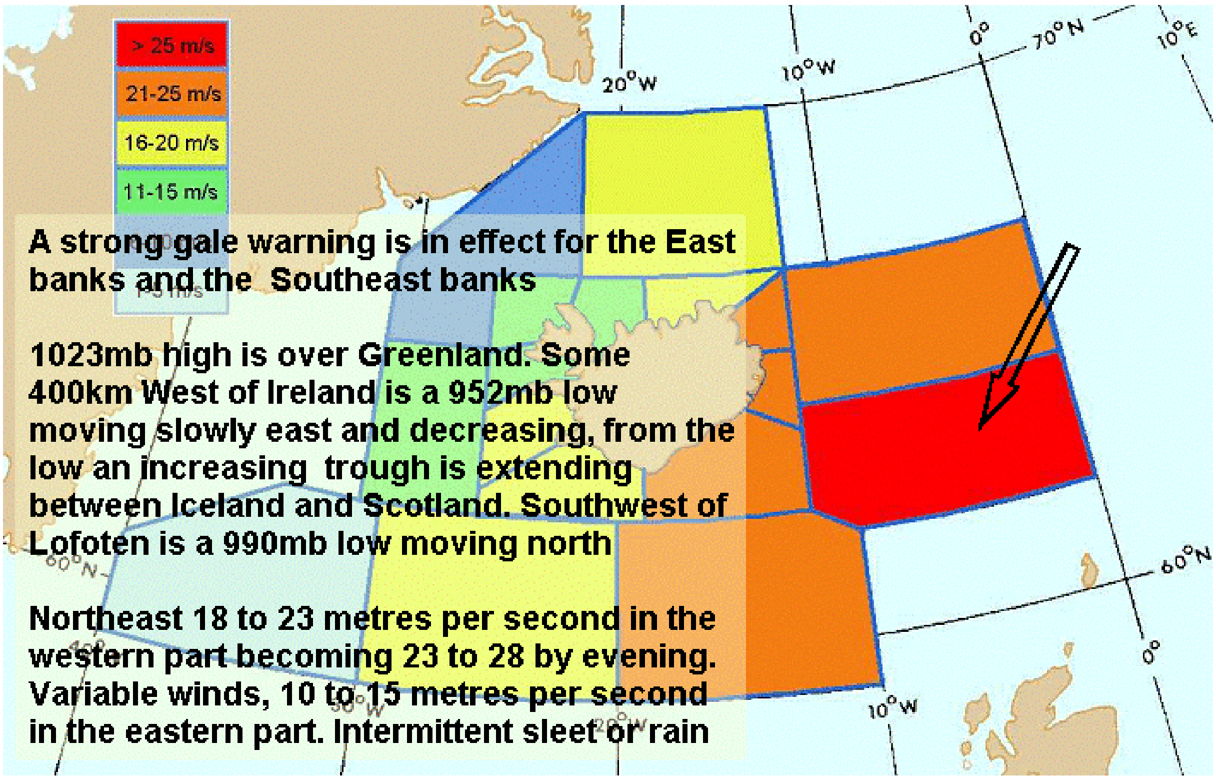


Figure 5.2. Example of text forecast combined with map information

Wave forecasts

The users will be offered the possibility to choose the desired area and the forecast period and they will get a picture showing significant wave height, mean wave direction and mean wave period. An example of a wave forecast is shown in Fig. 5.3.

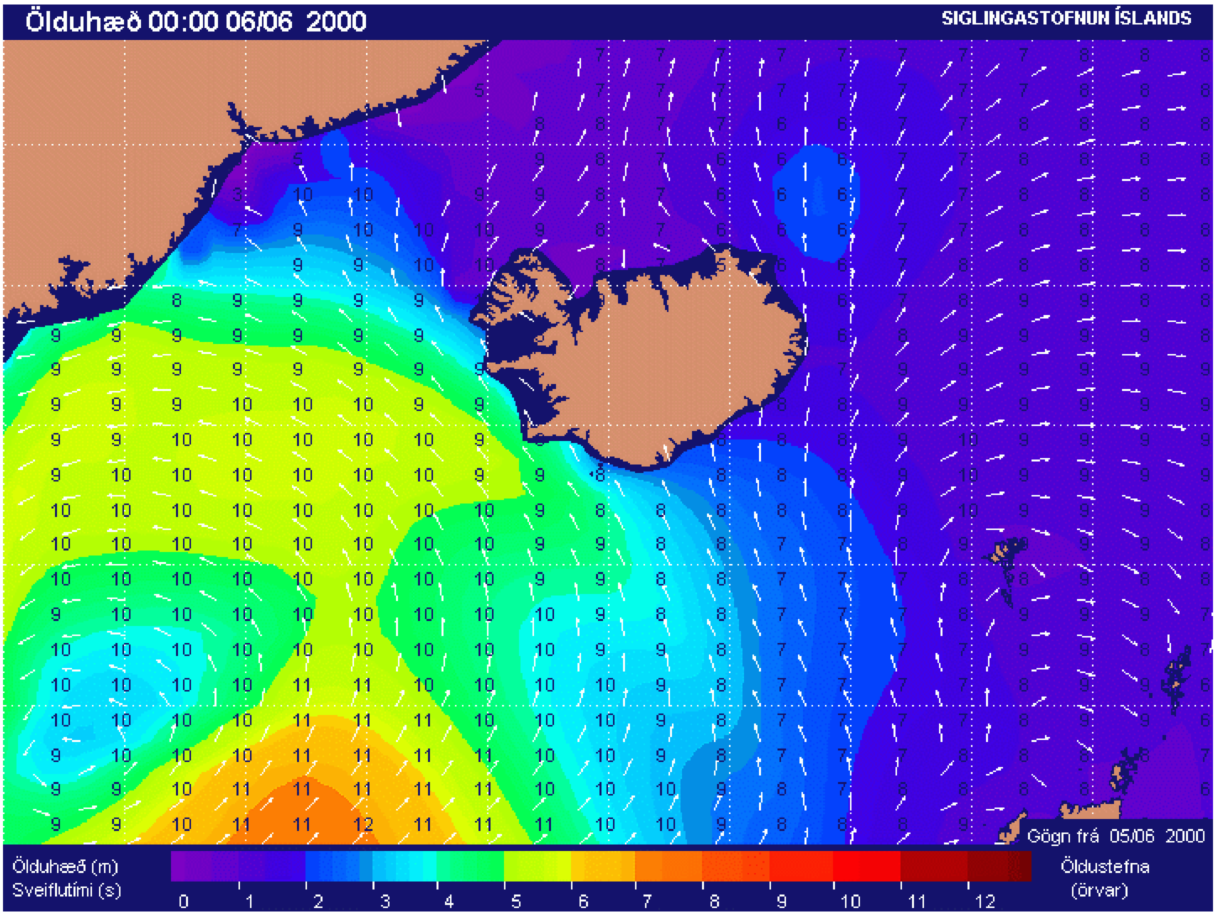


Figure 5.3. Example of wave forecasting map for Icelandic waters. Three parameters are indicated: Significant wave height (colour coded), mean wave direction (arrows) and mean wave period in seconds (numbers).

5.3 Baltic Sea Baseline System products (Thick Client examples)

5.3.1 Production aspects:

At the FIMR's Baseline system, two product chains have been adopted to IWICIS Baseline System: water level data (Fig. 5.4) and PWM wave model forecasts (Fig. 5.5). Ice applications are not included in the Baseline System tests, because they are operational only during the Baltic Sea ice season (October - May). However, an example of a SAR ice image is shown in Fig. 5.6.

Simplified description of the FIMR's water level data (example shown in Fig. 5.7) flow is as follows: The thirteen Finnish gauge stations are producing water level measurements 6 times a hour. Once every hour the measurements are transferred in ascii-format via modem to the FIMR. The ascii-data are deposited in FIMR's archive and in the web-pages of the Baltic Operational Oceanography System (BOOS) (http://www.dmi.dk/vejr/vandstand/boos.html) as well as in FIMR's web pages: (http://www3.fimr.fi/itamerinyt/?lang=fi). The data is also sent directly to customers via server of the Finnish Meteorological Institute.

For the IWICOS Baseline System production line, the ascii-data is changed into XML format and sent via the Finnish Ice Service to the Finnish Maritime Administration and from there to the use of operational Finnish icebreakers. This data is also sent to VTT for IWICOS presentation application development. Metadata files in XML format are sent to IWICOS Broker (Fig. 5.4).

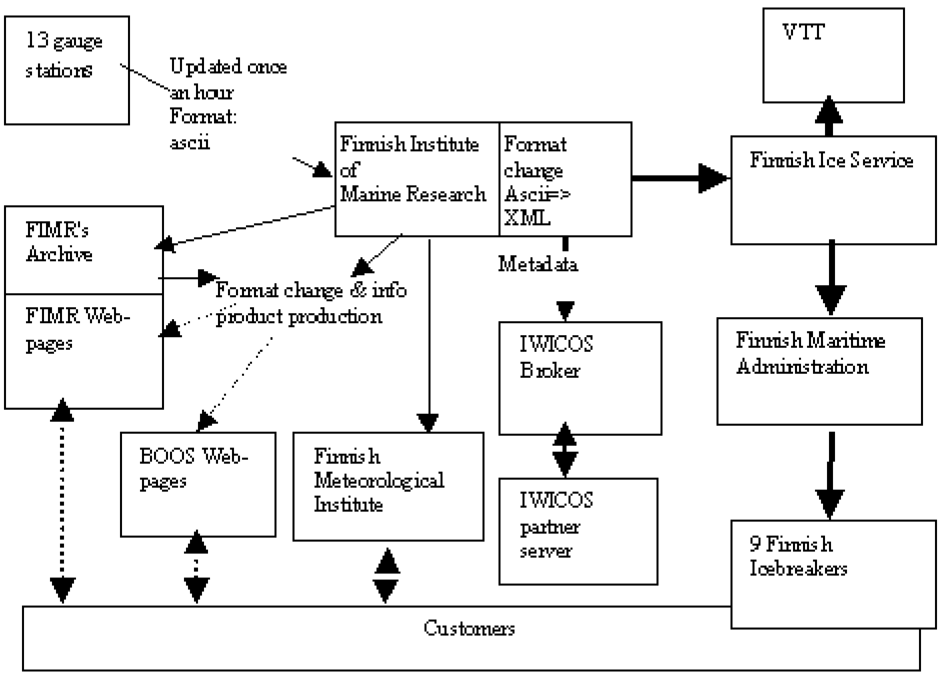


Figure 5.4 FIMR's water level data flow. Data is updated once a hour. Thin arrows: ascii format, thick arrows: XML format. Broken lines indicate various other formats.

FIMR's PWM wave model forecast data flow follow a similar structure (Fig. 5.5): As input data the Finnish Meteorological Institute is producing HIRWAM forecasts. HIRWAM is a combination of meteorological HIRLAM forecast model outputs and WAM wave model forecasts. Data of wave buoys is also used as input to HIRWAM; during the Baltic Sea ice season also ice extent in grid format is delivered by the Finnish Ice Service. The forecasts are run every 6-8 hours, i.e. during night time every 8 hours and during day time every 6 hours. HIRWAM forecasts are delivered to the FIMR in GRIB format. At FIMRthe format is changed into ascii and PWM model is run for +48 h forecasts. Forecasts are stored in the FIMR's archive in ascii format. Wave height and direction data of operational wave buoys is collected via modem and published viaa product procedure at the FIMR web-pages (http://www3.fimr.fi/itamerinyt/?lang=fi), and via an information chart production to Call-fax service, from where customers can pick-up latest forecasts by fax. The forecasts are also transformed into the wave height and direction forecast charts and GSM Short Message texts. These products are sent to customers via sever of the Finnish Meteorological Institute.

For IWICOS Baseline System production chain, the PWM's forecasts in ascii format are transformed into XML format and sent to VTT for IWICOS presentation application development. Metadata files in XML format are sent to IWICOS Broker.

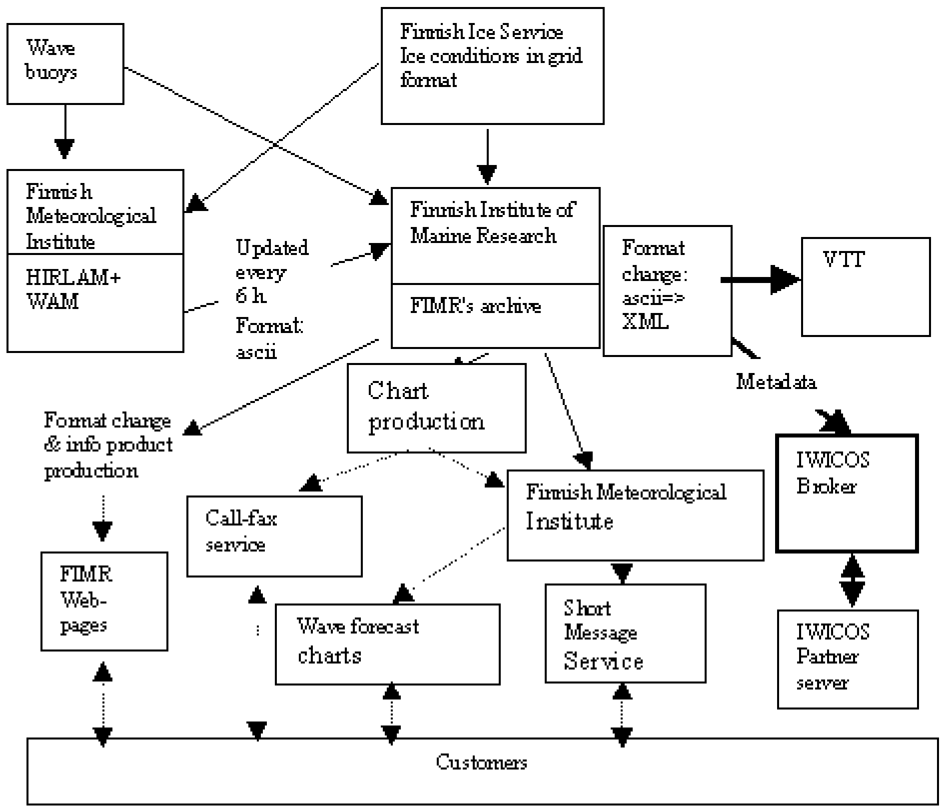


Figure 5.5 FIMR's WAM model forecast flow. Forecasts are updated once in 6 hours. Thin arrows: ascii format, thick arrows: XML format. Broken lines indicate various other formats.

5.3.2 Examples of products

The Baltic Sea Baseline System will use thick client approach to demonstrate the use of IWICOS data products in Baltic Sea area. The Client Software is built on top of pre-existing IBPlott and JGISFrame technologies developed by VTT IT. IBPlott software is extended with the capabilites to present met-ice-ocean information on a pannable and zoomable map.

The Façade converts the image data into ICE image format, which is currently used as format for satellite images in Baltic Sea area. ICE format includes geo-information, and it supports JPEG and GIF compression methods. Figs. 5.6, 5.7 and 5.8 show examples of products in the Baltic Sea.

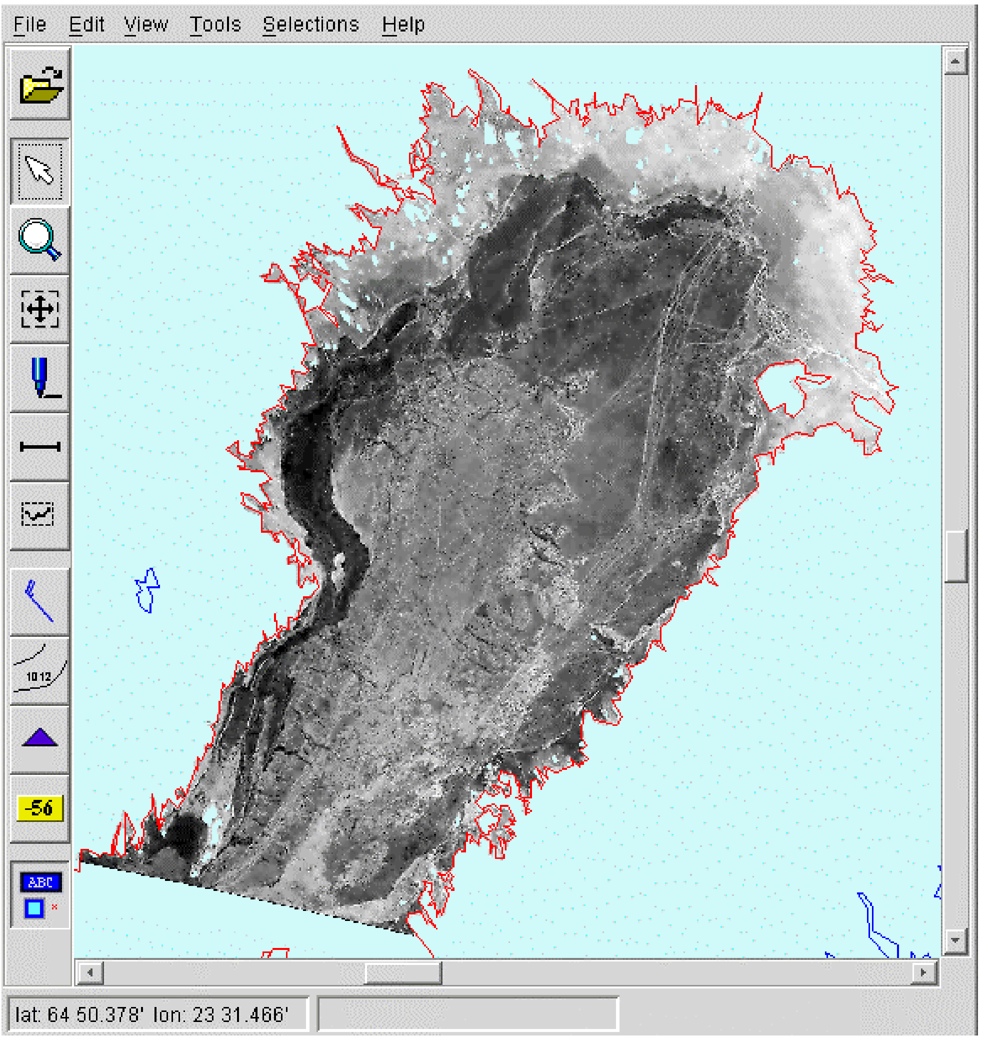


Figure 5.6. Radar satellite image of sea ice in Bothnian Bay.

Fig 5.6 illustrates a situation where user has opened a satellite image of sea ice and is able to zoom, pan and adjust the contrast to get the most out of the image. Many images can be opened at the same time, and they are presented as layered image mosaic on the screen. Façade filters the GRIB files received and delivers filtered files to Client Software. The client is able to produce images out of the GRIB files. Weather and ocean parameters that the client is able to present include wind, pressure, water level, and wave height. The parameters shown on the screen are selected by pressing the toggle buttons on the toolbar (lower left). Fig. 5.7 is an example of presenting pressure and water level parameters. Isobars are calculated locally on client side. Fig 5.8 depicts combined wind and wave symbols. The wave symbol consists of two components: an arrow presenting the wind wave component and an other arrow presenting the swell component. The length of the arrow indicates the wave length, and the area of the arrow head denotes the wave height. If given alarm limit is exceeded the symbol is drawn red. Tool tip gives accurate values for pointed symbol.

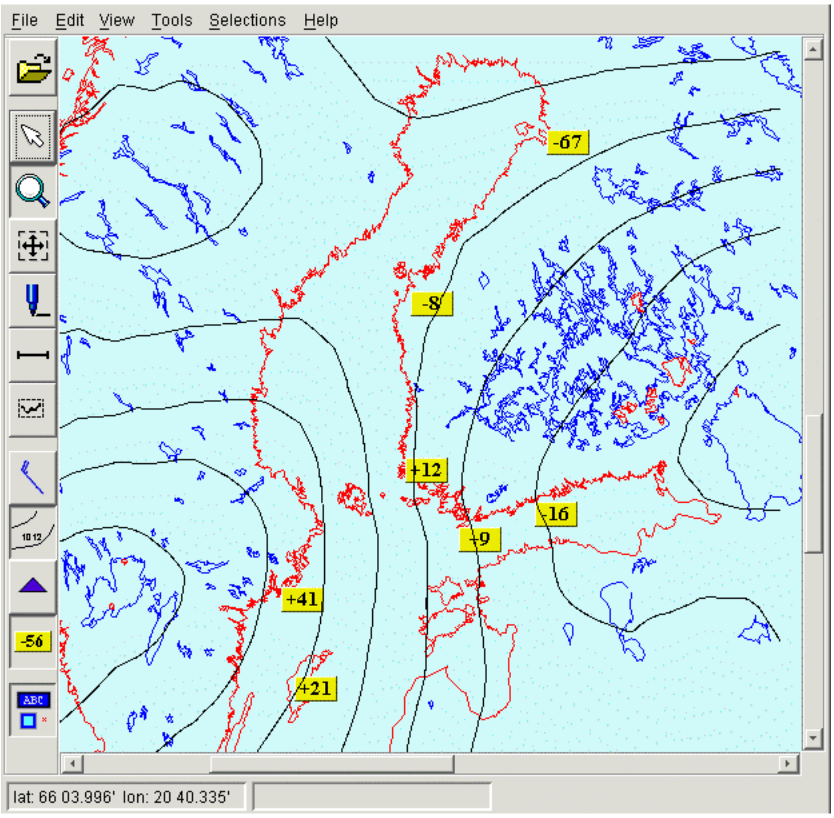


Figure 5.7 Water level and isobars.

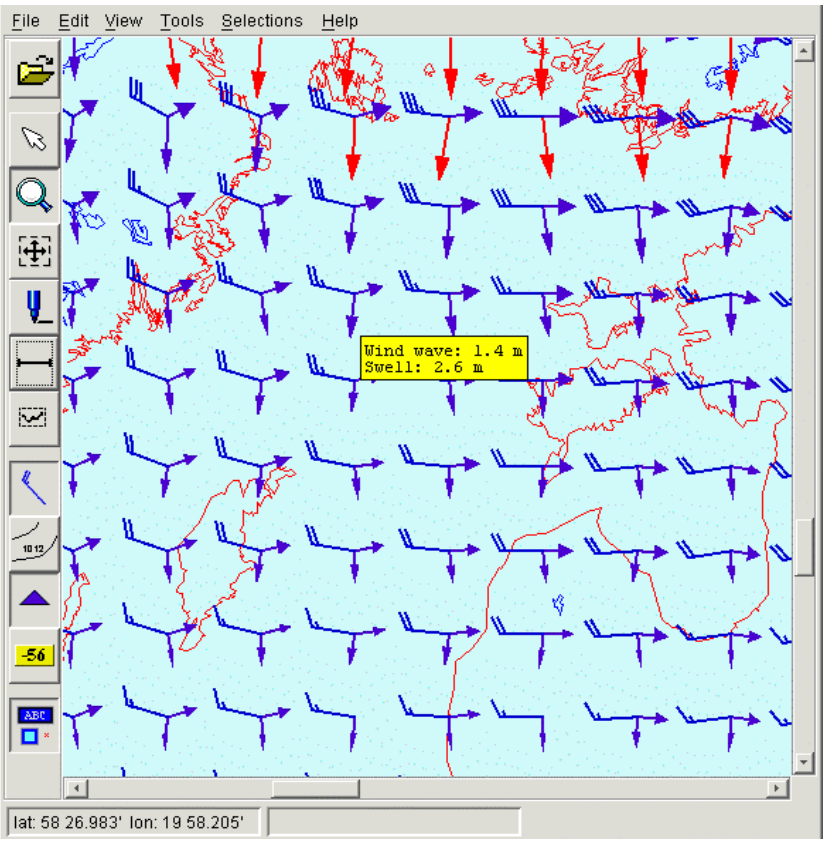


Figure 5.8 Combined wind and wave symbol.

5.4 The Met-Ice-Ocean Viewer (a thick client solution)

5.4.1 Introduction to MIO

A thick client solution has been developed and named the 'Met-Ice-Ocean Viewer' or in short the MIO Viewer. The client has been tailored to handle and present digital meteorological, oceanographic, sea ice data and satellite imagery, primarily to users onboard ships. The thick client is foreseen to serve those users that are considered 'off-line' users, i.e. users who only have access to data through narrow bandwidth connections. Users need to carry out both tactical and strategic route planning which involves analysis of sea ice, weather and ocean information. Today this information is available, but almost entirely as separate information layers. Therefore, users are interested in integrating weather, ocean and sea ice information in a more user friendly way and consequently benefit from the synergy that often will emerge when combining these data. By integrating different met-ice-ocean products in the MIO Viewer and combining these in a common presentation environment the user has a valuable tool when interpreting surrounding weather, sea ice and ocean conditions. Thus, the application is intended as a decision support and route-planning tool.

5.4.2 Baseline Products and Presentation Concepts

Currently the client system supports a number of products, which are targeted at the shipping community. The system can be extended to include more products/parameters if required by the user. Currently supported products are listed in Table 5.1.

CATEGORY	PRODUCT/PARAMETER	INPUT FORMAT
Satellite Image	RADARSAT	ERDAS, MrSID, BSQ
Satellite Image	NOAA AVHRR	ERDAS, MrSID, BSQ
Satellite Image	DMSP	ERDAS, MrSID, BSQ
Sea Ice Data	Ice Chart	Shapefile
Meteorology	Mean Sea Level Pressure	ASCII
Meteorology	Air Temperature (2 meter)	ASCII
Meteorology	Wind Speed/Direction (10 m)	ASCII
Oceanography	Significant Wave Height	ASCII
Oceanography	Mean Wave Direction	ASCII

Table 5.1 Products currently supported by the MIO Viewer.

The presentation of products seeks to follow known standards for viewing sea ice, meteorological and oceanographic data as defined in World Meteorological Organisation, 1970, World Meteorological Organisation, 1992 and World Meteorological Organisation, 1994.

Ice Chart
Sea ice analyses consists of ice edges, boundaries and information concerning the nature of the sea ice expressed in SIGRID codes. The ice analyses are translated into ice charts using WMO nomenclature when presented by the client system, e.g. by using ice eggs or presenting ice concentration through colour codes and hatching. In the case of ice concentration no official WMO standard exists at the moment for translating concentration levels into different colours and currently a DMI specific colour table is used.

Mean Sea Level Pressure:
Isobars are shown at intervals of 5 mbar and the 1000 mbar isobar is included.

Air Temperature (2 meter):
Isotherms are shown at intervals of 2ºC.

Wind (10 meter):
Wind barbs are used for point indicators.
Isotachs are shown at intervals of 5 m/s.

Significant Wave Height:
Isohypses are shown at intervals of half a meter.

Mean Wave Direction:
Mean Wave Direction is presented as vectors where propagating direction is given by an arrow and length of the arrow is proportional with Significant Wave Height.

5.4.3 Baseline System Data Flow

The data flow for the Baseline System is exemplified in Fig. 5.9. At product generation level several input data are used to generate an ice analysis leading to Ice Charts as data products.

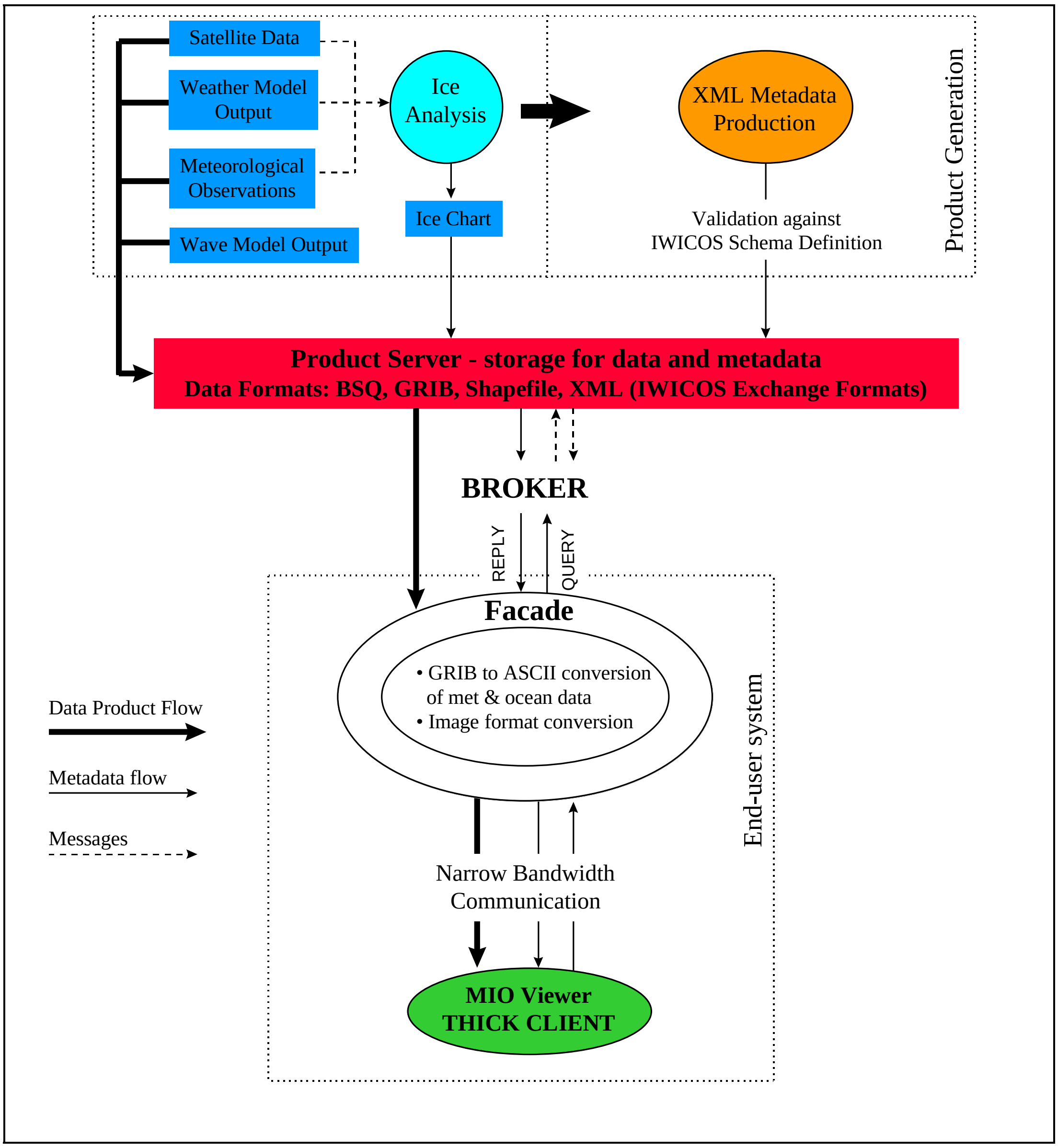


Figure 5.9: IWICOS Baseline System data flow in MIO

Ice Charts and other data products like satellite data and weather model output is stored on a partner specific product server. Metadata are generated from products and once validated against the IWICOS Schema Definition they are stored on the product server. A message is sent to the Broker every time a new product is available on the product server. The Broker then fetches the product metadata from the product server and stores it in a metadata database at the Broker.

The end-user system consists of a Facade-Client pair. The Facade acts as an interface between the client and the product server and handles data conversion from IWICOS Exchange formats to client specific formats. In the case of the MIO Viewer the facade converts meteorological and oceanographic data in WMO GRIB format to an ASCII text format which can be directly read by the MIO Viewer. Furthermore, the facade will be able to make image format conversion, e.g. from BSQ to MrSID resulting in a considerable size reduction which is preferable when sent through narrow bandwidth communication lines.

Due to narrow bandwidth, high communication expenses and other communication limitations users are only on-line while retrieving data from a data product server or a mail server. The mail server may be seen as a common storage environment between a product server and the client system. Whether data products resides on one server or the other the bottle-neck is related to the size of products and product packages transferred from the data location to the client system. Once data has been transferred to the client system further product generation and data conversion can take place.

Query functionality is part of the end-user system enabling the user to do query invocation based on query building in XML format. Queries are sent to the Broker query engine, which searches the metadata database and replies to the Facade with a XML reply set containing part of the product metadata or the full product metadata. Currently, no on-line queries are invoked from the client side during the first part of the MIO Viewer test phase. Instead, data provision is based on a data product profile as predefined by the user and the provider in collaboration. The data product profile is then adjusted from time to time according to sail routes, weather, ocean and sea ice conditions and data availability.

5.4.4 Thick Client Architecture

The MIO Viewer client is a customised and expanded version of the Geographical Information System 'ArcView' developed by ESRI Inc. The MIO Viewer data handling and processing depends on the input data. A schematic representation of MIO Viewer steps is shown in Fig 5.10.

The processing tasks are uniquely related to meteorological and oceanographic data. These are read as ASCII formatted data and then follows a three step processing sequence leading to three different products, one raster product and two vector products:

- Step 1: Converts from ASCII to vector format, the output being a point shapefile.

- Step 2: Based on the point shapefile generated in step 1 a spline interpolation is performed producing a Grid Surface in the ARC/INFO GRID format.

The Spline function ensures a smooth (continuous and differentiable) surface, which applies well to large-scale variations as observed in the parameters.

- Step 3: Based on the Grid surface a contouring is performed producing isobars, isotherms, isotachs, and isohypses.

Image data in the format of ERDAS, MrSID or BSQ is directly read by MIO Viewer and can be presented and visually manipulated using image contrast enhancement through an image legend editor.

Ice charts in the form of shapefiles are directly read by MIO Viewer and is presented using a colour code, hatching code or outline legend option.

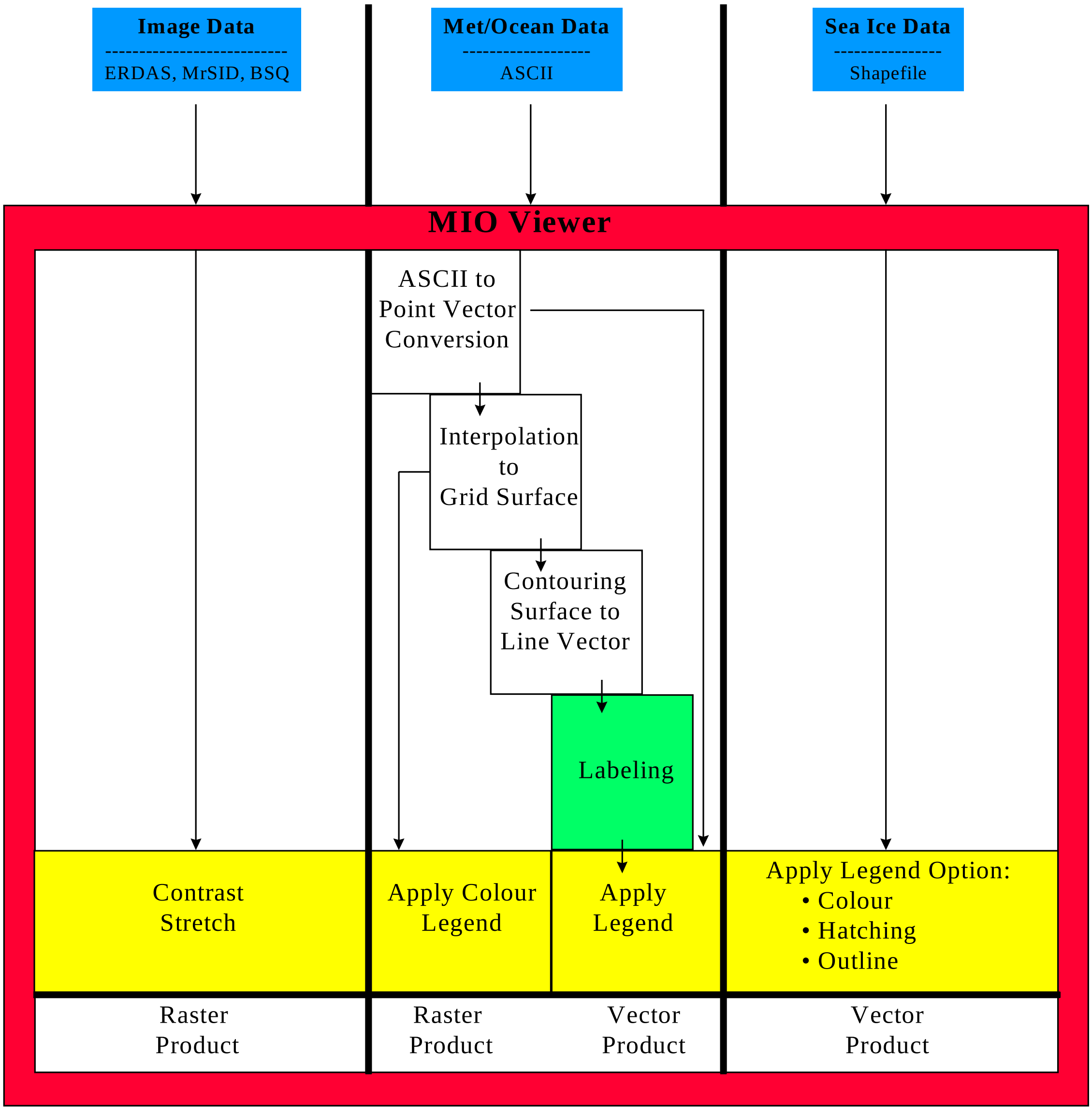


Figure 5.10: MIO Viewer processing chain and display process

5.4.5 Thick Client Functionality

The MIO Viewer utilises a substantial part of the basic ArcView functionality and furthermore, has been extended and customised to include functionality specifically developed for use by the marine user group (see Fig. 5.11).

The functionality as seen from the user perspective will be a mix of the basic GIS functionality as provided by ArcView and the IWICOS specific functionality developed using the Avenue scripting language. The IWICOS specific functionality can be divided into two parts, a data functionality part and a navigation/route planning part. The data functionality part is associated with the presentation of data products and extraction of their information content.

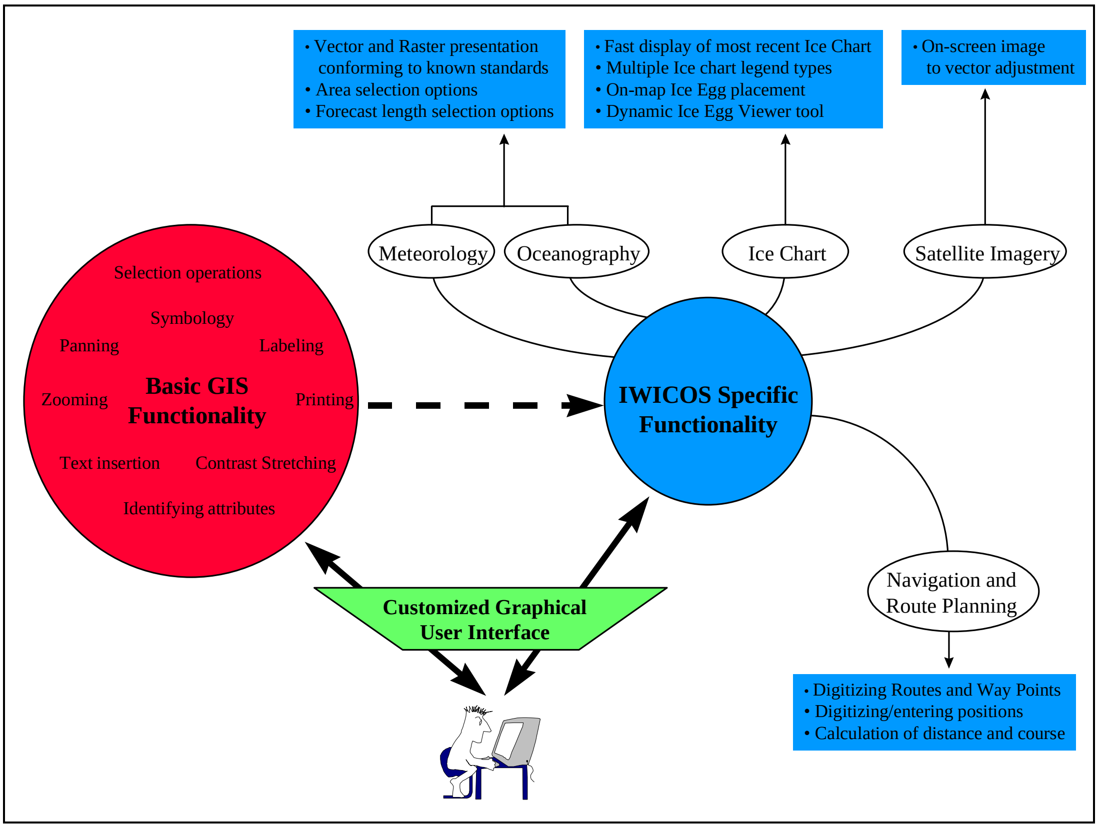


Figure 5.11: Generic functionality overview of MIO Viewer

The navigation/route planning part is associated with the process of digitising routes and waypoints and getting information on distance and course. All functions are available to the user through a customised graphical user interface

5.4.6 The Thick Client Graphical User Interface

The user interface has been customised in order to make application - user interaction intuitive and user friendly. This implies that certain basic ArcView interface parts have been adapted and new interface parts added in the MIO Viewer application. The main features having been considered in the user interface customisation process can be listed as:

- A clear, simple and logical design of the functionality environment.
- Functions should be accessed through menus, buttons and dialogues in accordance with other Windows applications.
- Quick access to certain important functions.
- Exhaustive information content in error and warning messages.

Examples of presentations by MIO are given in Chapter 6.1, showing results from the first testing in Greenland waters.

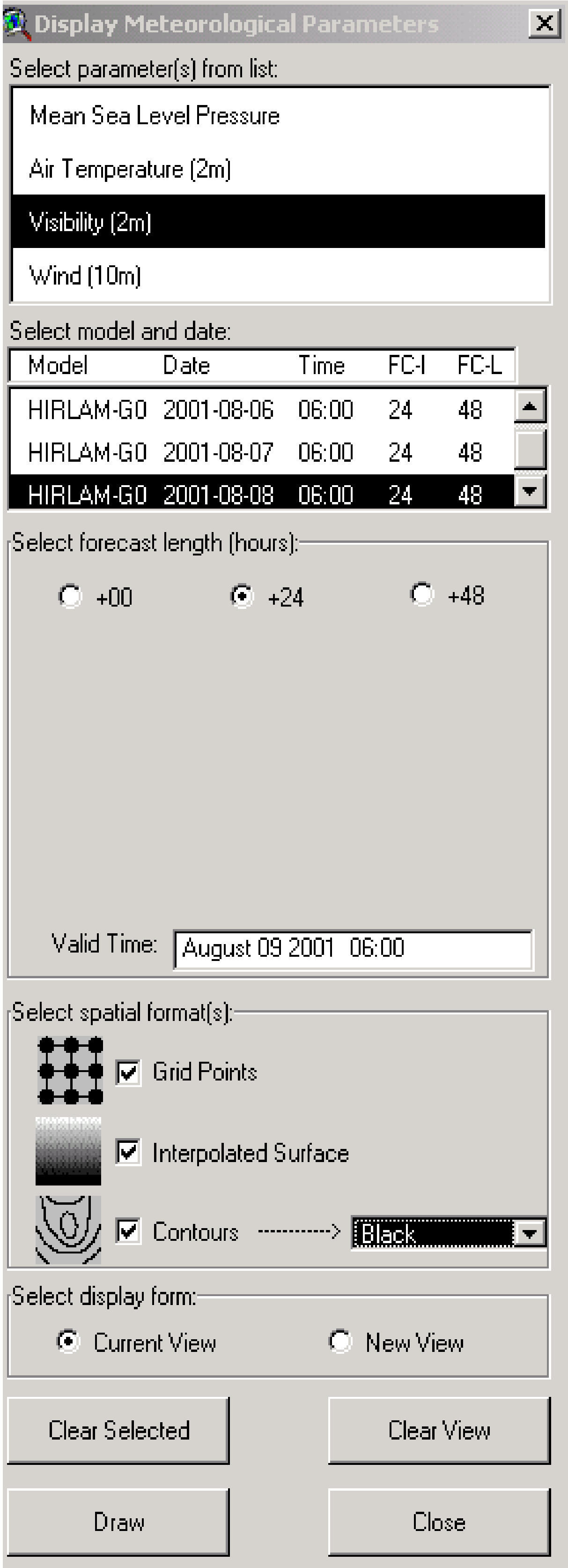


Figure 5.12: Dialogue used for presenting meteorology

Dialogues have been widely used for interfacing between presentation environment and actual data, e.g. when loading a meteorological parameter or an ice chart, see Fig 5. 12 and 5.13. respectively. Metadata are provided in dialogues in a form that gives a clear and precise overview of data thus, easing and speeding up the selection process as performed by the user. E.g. when a certain ice chart is wanted for presentation the user gets a list of available charts including information on valid date, valid time, area, primary source, secondary source and comments if any.

Fig. 5.13b shows a dialogue called 'Restructure View Contents' which is used for controlling the content of an active view.

In this dialogue the user can do the following:

- Get a list of data layers
- Remove selected data layers
- Set the visible status of layers
- Toggle on and off legends for selected data layers
- Get valid time for selected data layers

Several other interface parts have been developed:

- Dialogue for generating user specific met/ocean products (point shapefiles, GRID and contour shapefiles)
- Dialogue for deletion of met/ocean products
- Dialogue for quick changing of contour colours
- Tools for selecting and digitising positions and routes
- Buttons used as short cuts to frequently used functionality such as loading met-ice-ocean data
- Pop up menu choices used as short cuts to frequently used functionality such as zooming, panning, deselecting etc.

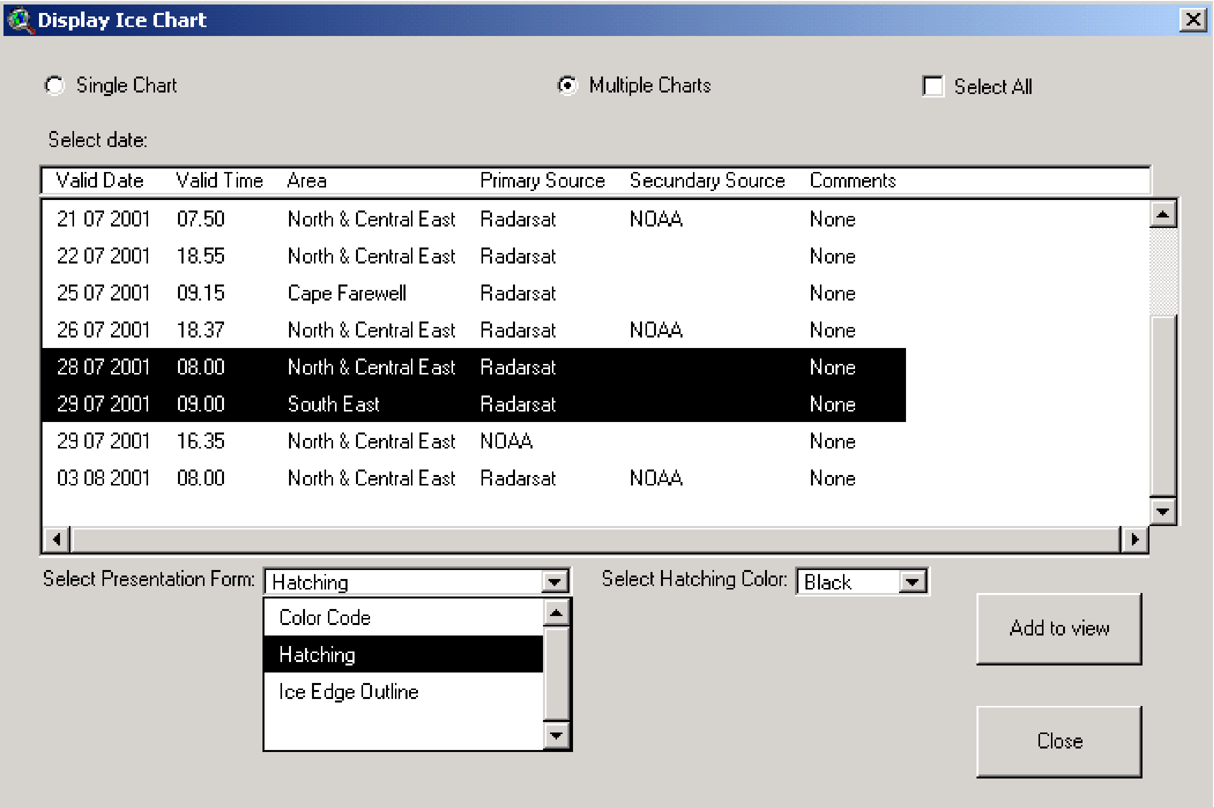


Figure 5.13 a: Dialogue used for loading ice charts.

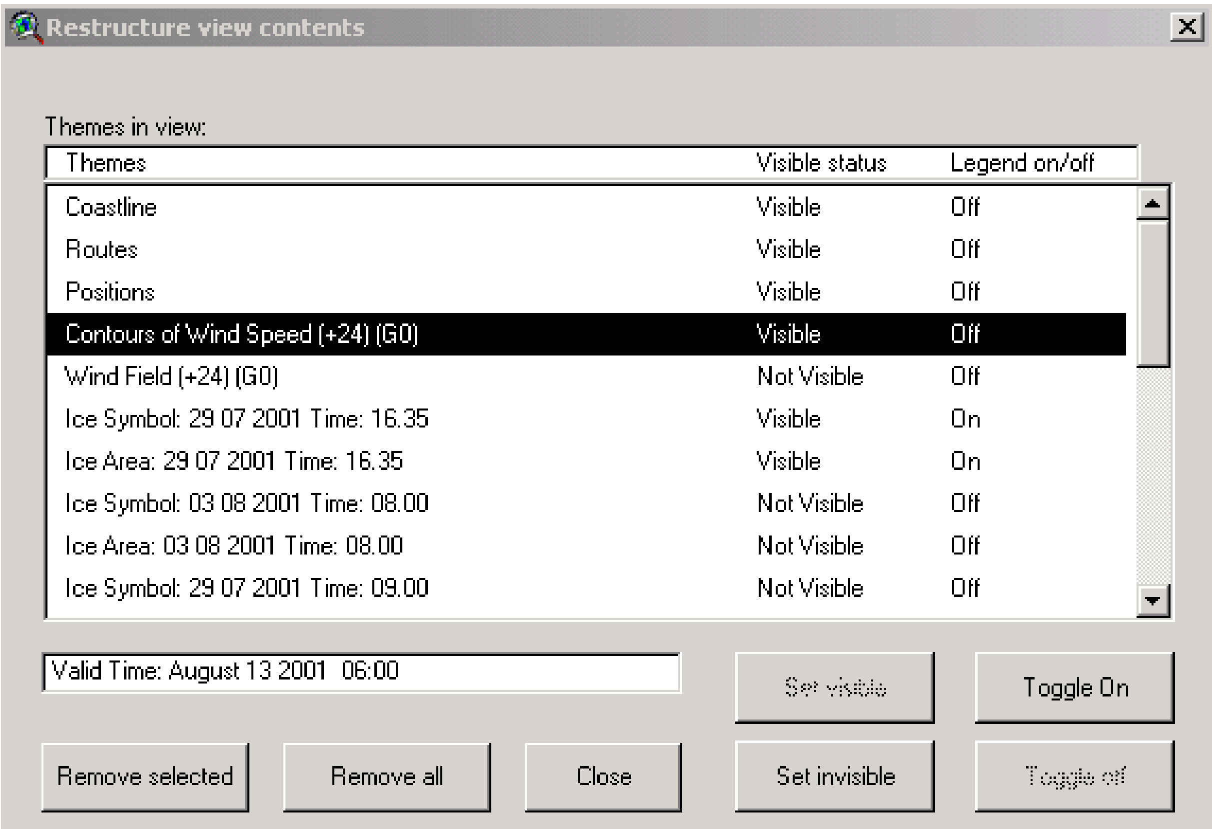
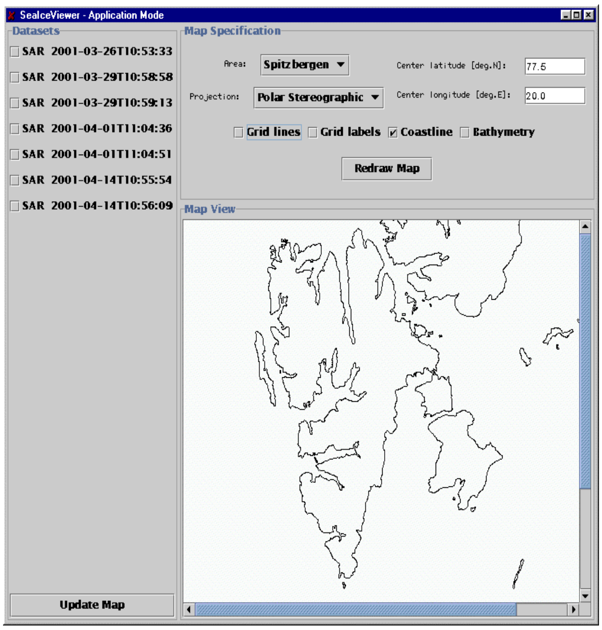


Figure 5.13 b: Dialogue used for controlling view content.

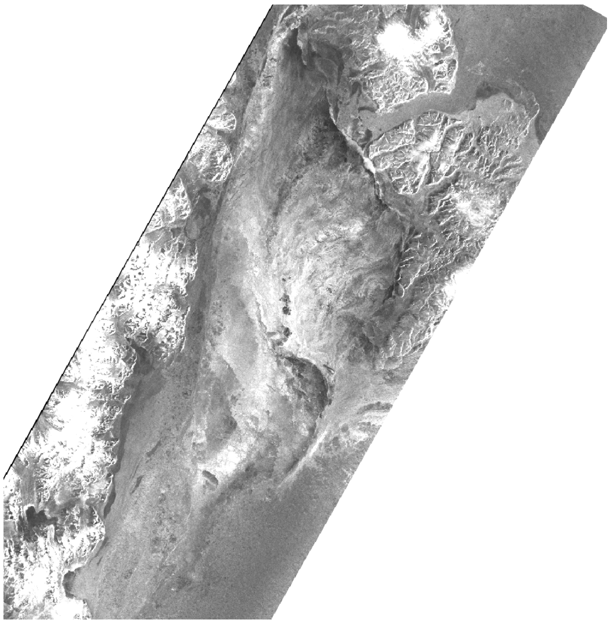
5.5 Balanced Client examples

5.5.1 SAR ice imagery and derived ice parameters

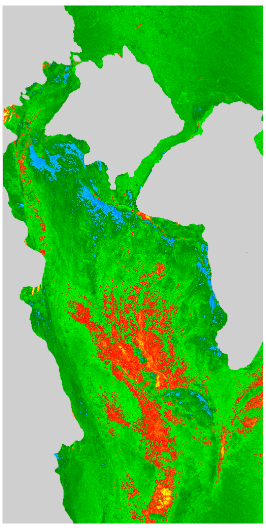
NERSC is developing a mixed thin and thick client for retrieval of SAR ice images and retrieved ice parameters such as ice classification and ice drift. In the baseline system, focus has been on implementing thin client capabilities, with display of metadata, SAR images and derived parameters. Fig. 5.14(a) shows an example of a map of the study area around Svalbard, which will show location of selected SAR images. Fig. 5.14(b)-(d) show examples of SAR imagery, ice classification and ice drift, respectively. XML metadata can be automatically generated from SAR images.



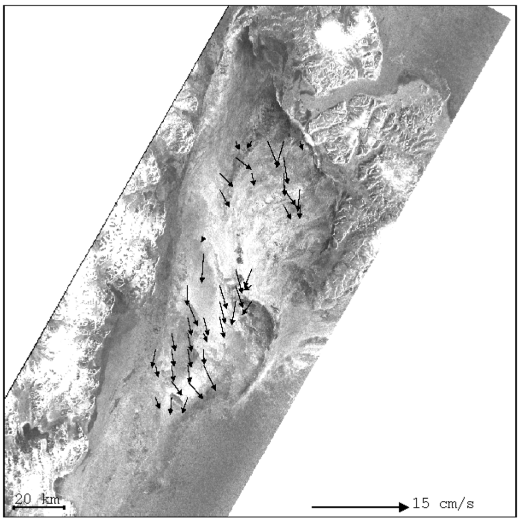
a) Localisation map



b) Georeferenced SAR image



c) Classified SAR image



d) ice drift vectors 17 – 20 April 2001

Fig. 5.14 Example of SAR ice products from the Svalbard area. . Colour coding of ice classification: blue=open water or thin ice; green=first-year ice; red-yellow=rough first-year ice.

Plans for future development of the SeaIceViewer application include incorporation of algorithms for SAR images, ice motion and classification (thick client), resolving technical issues for ice type classification (both thin and thick client), and streamlining the metadata/data production line for ice kinematics (both thin and thick client). NERSC also plans to include NCEP/DMI wind/SST data in the extended version of the SeaIceViewer client.

5.5.2 The DTU/DCRS Java browser

The concept of a balanced client lies somewhere between the thin and the thick clients described previously. The purpose of the development of balanced clients is to keep some of the capabilities of the thick client without having to install too much software. The JAVA programming language and the availability of standard web browsers with JAVA capability has allowed us to develop a limited amount of code that can be downloaded via the Internet or pre-installed if operated on a boat. The size of the code is in the order of 60 Kbytes, and it can be transferred over even very slow Internet connections in a very short time (seconds). The software is transferred automatically (if not cached) when the application web page is loaded.

Despite the small amount of dedicated code, the application allows a number of capabilities that are otherwise only available in thick clients.

These are:

- Display of images, and colour-/grey-scale manipulation
- Overlay of vector graphics including
    - Coastlines
    - Lat/lon grids
    - Contours of bathymetry
    - Contours of ice concentration (same day and previous days)
    - Digital ice charts (ice eggs and polygons)
    - Wind forecasts
- Zoom in/out
- Georeference (lat/lon coordinates at the click of the mouse)
- Distance calculations

The application is targeted at Internet users, but has also successfully been installed on-board ships during expeditions. The image data is all stored as using industry standard gif and jpeg formats in order to reduce data transfer. The database is designed and structured in a way that allows easy installation of subsets off-line. This enables us to transfer subsets of data to off-line (on ship) users using Inmarsat of Iridium satellite communication systems. In order to reduce data transfer, we take advantage of the caching capabilities of the standard Java browser.

Fig. 5.15 below shows an example of a screen shot from the JAVA application. The figure illustrates some of the capabilities of the system.

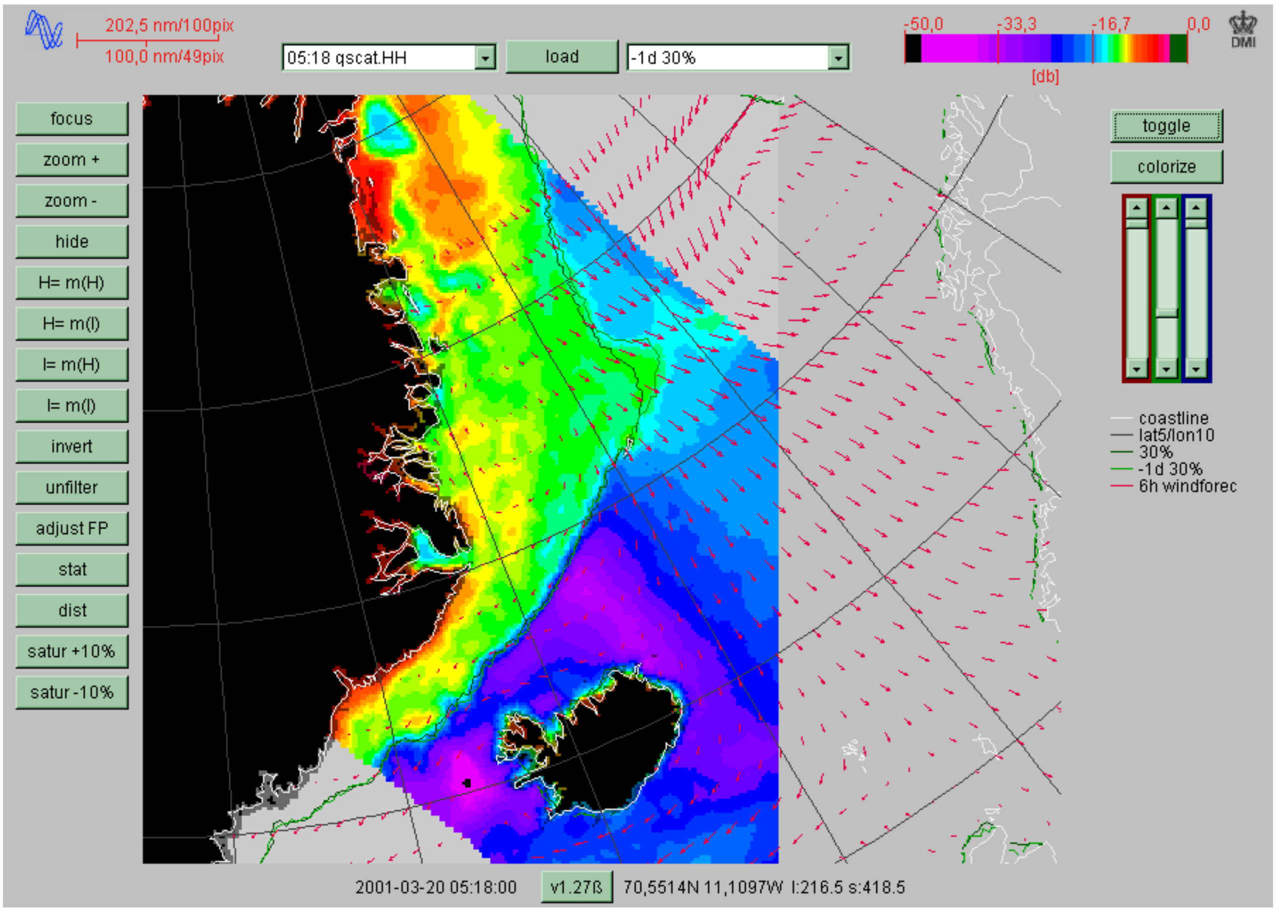


Figure 5.15. The baseline DTU/DCRS IWICOS met/ice/ocean browser. The imagery is from NASA's QuikSCAT scatterometer instrument 05:18 UTC on March 20, 2001. Overlays are coastline, lat/lon grid, 6 hour wind forecast valid at 06:00 and 30% ice concentration contours from March 19 and March 20.

6. Testing and preliminary assessment

6.1 Testing in the Greenland Sea

The MIO Viewer Baseline Version has been tested onboard the vessel Kista Arctica, Royal Arctic Line in the period from 1st of July - 14th of September 2001. The number of cruises carried out during this period amounts to the three and their track are shown in Fig. 6.1. During these cruises the vessel has been provided with meteorological/oceanographic data, sea ice data and satellite imagery. Examples of products are shown in Fig 6.2 and 6.3. Table 6.1 lists the various parameters delivered. Prior to delivery, data are assembled in packages and subsequently compressed. Table 6.2 lists the file size and communication line for the data provision set-up.

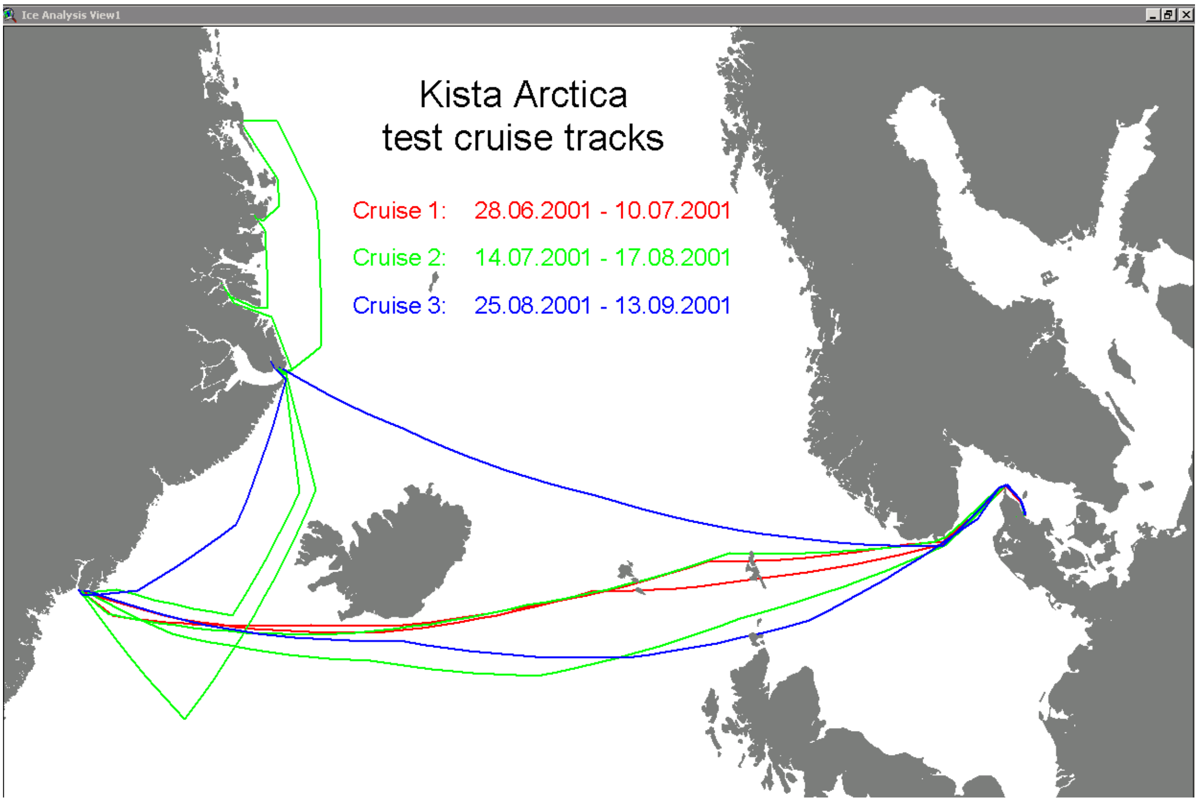


Figure 6.1: Cruise tracks of the Royal Arctic Line vessel Kista Arctica on which the MIO Viewer has been tested in the summer of 2001.

Preliminary user response

The response from ship captains so far is sparse, but a more thorough evaluation of the first test will be accomplished in October-November 2001. However, the comments received can be divided into two categories - a) comments related to data/data provision and b) comments related to the MIO Viewer functionality. Comments are from the two captains which have been operating Kista Arctica during the test cruises. The important response we get from these tests concerning system performance forms the basis for adjustments and implementation of new features. Thus, the further development of the system is done in close collaboration with the user community.

Table 6.1: Data delivered to Kista Arctica during baseline test.

CATEGORY	PARAMETER	FREQUENCY	PROGNOSIS
Meteorology	Mean Sea Level Pressure	1 pr. day	0, 24, 48h
Meteorology	Air Temperature (2 meter)	1 pr. day	0, 24, 48h
Meteorology	Wind Speed and Direction (10 meter)	1 pr. day	0, 24, 48h
Oceanography	Significant Wave Height	1 pr. day	0, 24, 48, 72h
Oceanography	Mean Wave Direction	1 pr. day	0, 24, 48, 72h
Sea Ice	DMI Ice Analysis	app. 3-6 pr. week	
Satellite Imagery	RADARSAT sub-images	irregular	

Table 6.2: Data packages sent to Kista Arctica.

CATEGORY	FILE SIZE	COMMUNICATION LINE
Meteorology	Steady: 33 Kb (zipped)	Inmarsat-B 9.6 kbit/s
Oceanography	Steady: 13 Kb (zipped)	Inmarsat-B 9.6 kbit/s
Sea Ice/Satellite Imagery	Varying: 30 - 200 Kb (zipped)	Inmarsat-B 9.6 kbit/s

Comments related to data

The initial areas were too small and unnecessarily detailed - the area should be one large rather than several smaller although it implies a lower of spatial resolution if file sizes are to remain unchanged.

It is strongly desirable to have fronts and low/high pressure symbols positioned together with mean sea level pressure.

We only need one daily broadcast of met and ocean data. The reason for this is the communication expenses and the fact that we primarily use broadcasts in the morning. Therefore, a one day broadcast should be based on a morning analysis.

Prognosis should be extended to include 72 and 96 hours for both met and ocean data.

Comments related to the MIO Viewer

It would be desirable to be able to save, load and edit routes digitized in MIO Viewer. In this way we would be able to save the route at the beginning of the cruise and load it into another view later on for further editing.

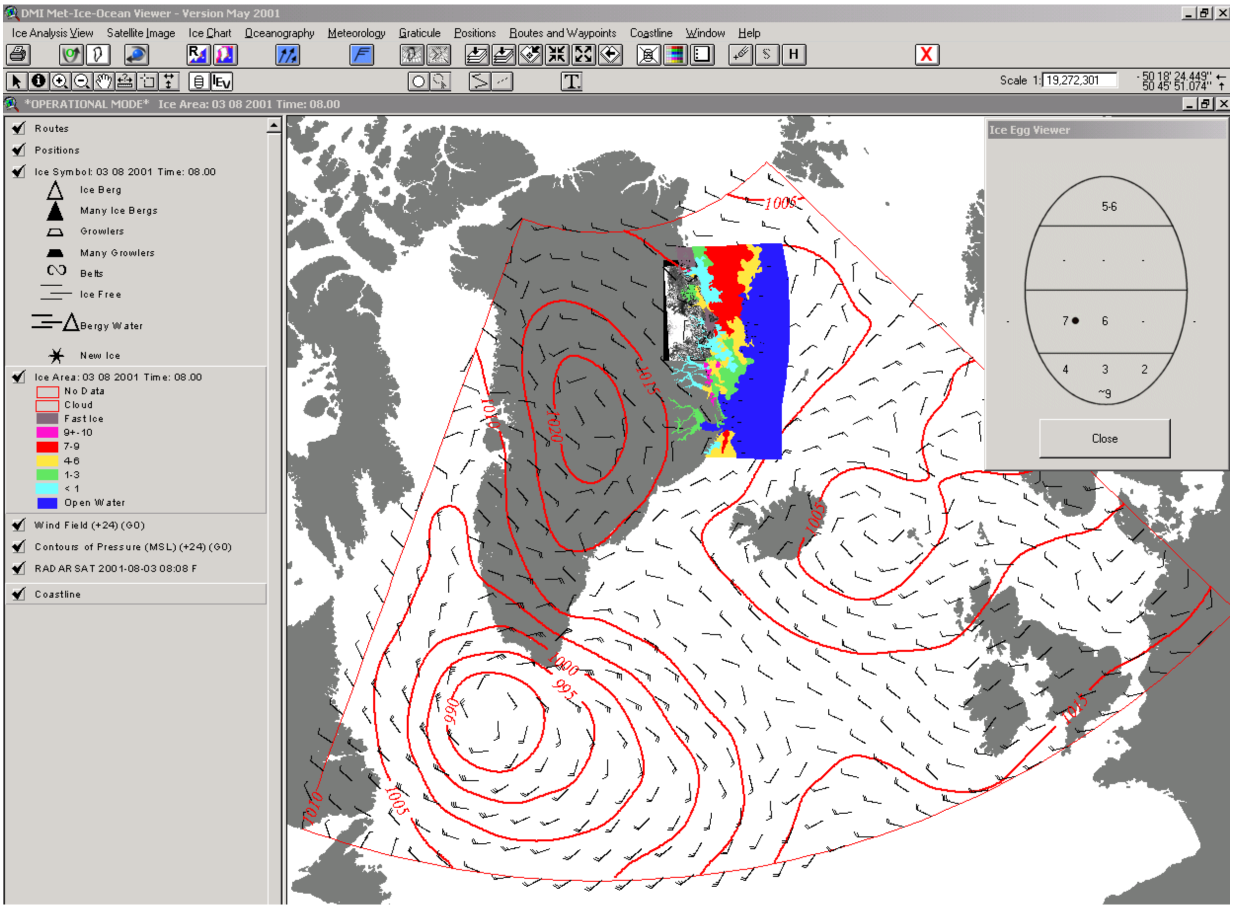


Figure 6.2: 24-hour numerical prediction of MSL pressure and 10 meter wind from the DMI-HIRLAM-G model, 3/8 - 2001. Furthermore, a RADARSAT image and DMI colour coded Ice Chart from 3/8 - 2001 is shown. The Dynamic Ice Egg Viewer tool is shown in upper right corner displaying ice information when mouse clicking ice chart polygons.

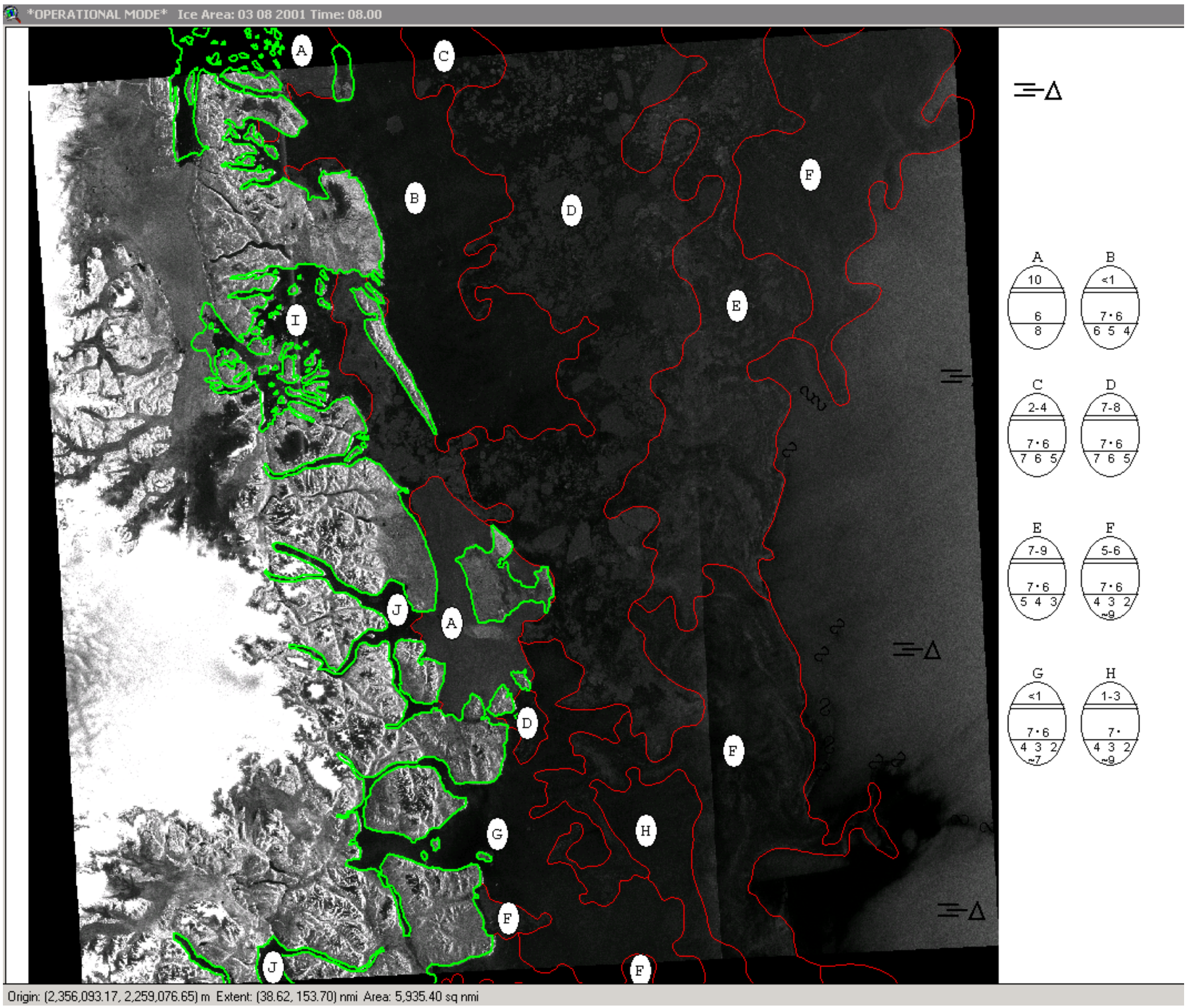


Figure 6.3: Close up on RADARSAT image and DMI Ice Chart from 3/8 - 2001 covering the area around 'Danmarkshavn'. Ice areas are outlined (red) on top of image and ice information is given as 'on-map-placed' ice eggs.

6.2 Testing in the Baltic Sea

In May 2001 some of the Baseline Products were shown to a group of users representing the icebreaker captains in Finland and Sweden. Because of the late date the demonstration took place at VTT.s premises in Espoo. The users had the possibility to get acquainted with the application in advance, but they did not have had much time to do this. The main focus was on the weather forecast presentations. The comments from the users were concentrated to details of the presentation part:

- The time of the first valid forecast time and the issue time of the forecastshould be more clearly shown. The present implementation did not indicate the time of the forecast very well.
- Loading of weather forecasts should be automatic. This will also hide the details of loading the forecast possibly consisting of many files, each containing a separate area or separate attributes.
- Cleanup of old forecasts should be automatic. This will also help the user in operational situations.
- The time should be local time (or UTC as an option).
- One of the captains did not see the usefulness of very detailed prognosis, but more experience is needed to evaluate the use. This is the reason for doing demonstrations - not until there are experience from a longer time and the users know the possibilities, is it possible to evaluate the real usefulness of the system.
- About water level: a prognosis values should be shown differently from observations, perhaps should the prognosis values be shown in italics.
- Wind observations: A Finnish captain proposed a circle with a value inside for visualizing observations as opposed to the prognosis field.
- Isolines should be more extensively used such as for wave height, wind etc. The problem is how to combine many types of information and still maintain a clear overall view.

7. Market study summary

7.1 Introduction

In Europe the sea transportation has grown and is growing rapidly. The latest White Paper of the Commission of the European Communities (2001) states (p. 42): "Short-sea shipping carries 41% of goods traffic within the Community. It is the only mode of goods transport within a growth rate between 1990 and 1998 (+27%) approaching that of road transport (+35%). In millions tonne-kilometres, the volume of trade carried between 1970 and 1998 increased by 2.5, representing 44% of the total volume and 23% of the total value of the goods transported within Europe." In addition to transportation, there is significant fisheries in European Seas, and Iceland is a major fishery country where there is a market for met-ice-ocean services to fishing vessels.

7.2 The Baltic Sea market

The Baltic Sea freezes annually and the maximum annual ice cover ranges from 12 to 100% of 420,000 km^2 being on average 218,000 km^2. The ice season begins in October - November and ends in early June. Thus depending on the sea area and severity of ice season, it lasts from a few weeks in the south to six months in the north. During mild winters, the sea ice causes navigation difficulties in Finland, Sweden, Russian and Estonia. In average and severe winters, ice affects all the Baltic Sea countries.

In the Baltic Sea some 80-90% of the foreign trade is marine transported. The total amount of cargo turnover (freight) in the Baltic Sea is more than 700 million tons (1999), some 40% of which occurs during the winter. This makes the Baltic Sea the most heavily marine operated area in the world, where seasonal sea ice plays an important role in navigation. Number two is the Gulf of St. Lawrence in Canada with about 180 million tons (1997) transported annually. E.g. in Finland 90% of foreign trade is marine transported with annual turnover of over 80 million tons (2000). During the winter months there are over 25,000 port-calls at the Finnish harbours and more than 30 million tons (2000) of goods are transported.

During the last 10 years, also the Finnish shipping has grown by 30% and similar trend is expected to continue. However, the number of icebreakers has not increased during the same period. Smooth traffic arrangements have been ensured by better ice monitoring, e.g., use of satellite data. Icebreakers cannot assist all vessels individually, and therefore more detailed ice information is needed for route planning. If these demands could not be answered ships cannot hold their time-tables and transporting costs will arise more than necessary.

Over the years the transportation chain has become more effective and schedules have been tightened rapidly: goods must be transported in minimum time from producers to consumers. Schedules in marine transportation have also tightened. This means that customers are expected their goods transported very fast regardless of weather or ice conditions. Delays in marine transportation effects negatively to the whole transportation chain.

The ships need weather, sea ice and ocean information and forecasts for a) effective time table planning, b) effective route planning, c) secure navigation conditions for ships and cargo and d) minimising for transporting costs.

Conclusions for the Baltic Sea

- The economic value of sea transportation of goods in Europe is large. In 1990s its volume has grown for 27%, and its future grown is expected to continue at the same rapid level.

- The economic value of winter navigation in the Baltic Sea is large, and ice navigation is vital at least to Finland. By improving the sea ice monitoring, and high-resolution data and information product distribution, considerable savings could be achieved in ice navigation, mostly by reducing sailing times. This would mean a large spectrum of various kind of met-ice(-ocean) data and interpretation products, and forecasts.

- Interest for digital met-ocean information products for open water navigation is increasing. The ships need this information for e.g. route optimising, cargo secure, passenger comfort and sea safety.

- A trend towards a fully digitised information system on board ships can be perceived. The development of digital information systems for ships, including digital sea ice charts and other high-resolution data and forecasts like met and ocean products, will have a strong impact on the development of information producers systems.

- New communication systems will be available in the near future. New communication satellites able to transfer high data rates at reasonable price level are expected to be operational in on a large scale in the near future. Providers of sea ice information products should take advantage of the new communication technology by developing high-resolution information products to be used directly in ice navigation.

- Fishing vessels have requirements for tailored met-ice-ocean products. In near future pleasure boating seems to be the fast growing market for digital met-ocean information products. Low cost cellular telephone technology with Internet-kind solutions seems to be answer to the user requirements.

- Met-ice-ocean data and forecast producers should change their production chain, so that high resolution products could be delivered to professional users and more general information products to those who's requirements are more modest. The users require more and more tailored products instead of general products.

7.3 The Icelandic Market

The Icelandic waters cover a very large area where unstable weather can often be expected. This market study was mainly focused on fishing boats as fishery is the most important industry in Iceland. The market is quite big, about 2200 vessels, of which about 1900 are smaller than 100 tons and 300 larger than 100 tons.

The needs for those two different groups are very different. Small boats are fishing close to the shore, but often far enough to be out of range for mobile phones. Sophisticated technical equipment is not affordable for them. Large boats go much further out and their communication possibilities and technical equipment can be very different from the first group.

The results are based mainly on a user survey carried out on behalf of IWICOS, a survey made for the Icelandic Meteorological Office among the Icelandic public and a special communication study made by Radiomidun. These surveys are followed up and supported by informal and formal meetings with users and service provieders.

As the results are common for the different user groups in some areas and quite different in other areas they will be presented in three parts:

1. All users rely heavily on weather information on radio at all times and they are in general quite satisfied with the current situation of getting textual forecasts and warnings. They use the Internet less than other groups in the society and they would still use radio even if they had all possibilities offered on shore regarding communications. Weather forecast is most important of all met, ice and ocean products for all users but wave forecast is considered important as well. When asked how users want met-ice-ocean information presented to them a majority expresses interest for some kind of pictorial information with explanatory text, but very few want detailed pictures.

2. Small boat owners rely very much on Text TV and more than other groups. They also use IMO's telephone answering machine frequently and much more than other groups. They use NMT-

phones (Nordic Mobile Telephone) when they are out at sea and they are in contact most of the time. Small boat owners show little interest in sea ice information and are not willing to pay for it.

3. Most large boat owners have the MaxSea application from Radiomidun installed and some of them use radiofax to get forecast charts from the British Meteorological Office. They express interest in sea ice information and they are willing to consider to pay for detailed information on sea ice.

A communication study was also carried out on behalf of IWICOS. The main results are as follows (se also Table 7.1):

To make use of all IWICOS products possible, especially graphic products like satellite pictures, the users will have to rely on satellite communication. This type of communication has suffered because of the enormous popularity of domestic communication networks like GSM. Smaller boats will have to rely on simple communication systems as NMT which will seriously limit their use of IWICOS products . As NMT will probably be phased out over the next 3-7 years some inexpensive global communication solution will be needed. Use of satellite systems is expected to triple over the next two years.

Table 7.1. Communications Systems today and 2003 (predicted)

Comm. System	Data transm. speed	Coverage	2001 Installations July 2001	2001 Data connected	2003 Data connected	Diff. in numbers	%
GSM	9.6 Kbs	Domestic	20	15	45	30	12
NMT (Nordic Mobile Telephone)	4.8 Kbs	Domestic	1.200	250	100	-150	-61
Tetra	14.4 Kbs	Domestic	2	2	250	248	101
Vsat	2 mbs	N-Atlantic	1	1	3	2	1
Inmarsat-A	9.6 Kbs	Up to 77 lat.	1	1	0	-1	0
Inmarsat-B	9.6 Kbs	Up to 77 lat.	6	6	6	0	0
Inmarsat-B (HSD)	64 Kbs	Up to 77 lat.	0	0	2	2	1
Inmarsat-F4	64 Kbs	Up to 77 lat.	0	0	10	10	4
Inmarsat-C	Store/forward	Up to 77 lat.	225	225	225	0	0
Inmarsat-MiniM	2.4 Kbs	Up to 77 lat.	20	20	40	20	8
Iridium	2.4/10 Kbs	Global	15	5	55	50	20
Emsat	4.8 Kbs	N-Atlantic	20	20	25	5	2
Globalstar	9.6 Kbs	Up to 77 lat.	5	0	25	25	10
HF-Radio data	0.5 Kbs	N-Atlantic	0	0	5	5	2
			1.315	**545**	**791**	**246**	**100**

8. Internal evaluation

At the Midterm meeting an internal evaluation was carried out where the status of the project was compared with the objectives stated for the IWICOS system . The comparison is shown in Table 8.1.

Table 8.1: Internal evaluation of the IWICOS project at Midterm meeting.

1. The IWICOS system should take into account the different needs and educational background of the users	The design of IWICOS is made to satisfy different needs of the users, ranging from expert users to laymen who only need to access simple and ready-made products. This is also the background for developing several thin and thick clients instead of one end-user system
2…combine information from different sources	The architecture of IWICOS and choice of metadata standards is based on this requirement
3. develop a single-entry point system	This is not yet done, but several elements which are necessary for a single entry system have been completed (metadata, standard formats, etc.)
4….user-friendly interface	The thin and thick clients will have user interfaces which accomodate standard symbols, nomenclature, multi-lingualitiy, etc. which are common in met-ice-ocean services. Use of GIS technologies has a central role
5. follow standards	See comments above
6. dissemination and exchange of data sets and products	Standard exchange formats are BSQ, GRIB, Shapefile and XML. (XML is used both for metadata and data.)
7. communication limitations	The façade – client interface takes into account that some clients will use only low bandwidth communcation
8. wide range of products	The term “product” has been defined more explicitly, and we have divided products into two categories: initial products and client products. The latter, which are important for the users, will include many different products, depending on the client
9. cost issues, payments and e-commerce	IWICOS is designed with possibilities to implement payment of products and services using e-commerce under control by the service providers

9. Plan for the Extended System and demonstrations

9.1 Introduction

The main features of the extended system are: (1) the broker will be activated, (2) a single-access entry point will be implemented, (3) the clients will be further developed and, (4) more advanced client products will be developed based on the fact that the broker is operational. The demonstrations will also be important because external users will see how the clients work and will provide evaluation and assessment of the IWICOS system

9.2 Plan for the Icelandic services

IMO's contribution to the baseline system consists of two products which are very essential to seafarers, particularly for those on smaller boats which are the main target group of IMO. For the extended IWICOS system IMO has planned to add several products.

Enhancements of presentation of textual forecasts and warnings

It is desirable to improve the possibility to choose the wanted part of the forecast. In the very simple baseline system the possibilities are rather limited because of the restriction that only four gridpoints can be used to describe an area. The shape of forecasting areas at sea is normally more complicated.

Text forecasts will also be implemented in Radiomidun's thick client, MaxSea.

Warnings for strong winds, high waves, ice accreation etc. are the most important part of any marine weather service. They must therefore be handled in a satisfactory way in the extended system. Coordination of warnings between neighbouring weather services, which might be forecasting for the same areas, is assumed to be very important and will be considered carefully.

Point forecasts

Successful attempts have been made to produce local forecasts automatically by applying statistical methods to adjust the output from numerical prognostic models, mainly wind speed and temperature, to weather observations. Such forecasts for selected weather stations on the coast will probably be valuable for seafarers. The presentation of such forecasts is easy and suitable for limited bandwidth. They may even be distributed as short messages for mobile phones.

The feasibility to produce similar forecasts for wave buoys will be investigated.

Ice charts

Sea ice charts for the area north and west of Iceland will be produced and presented to the users. The charts will be based on NOAA AVHRR and SAR (ERS, Radarsat and Envisat) images. The work will include investigation of the quality and other properties of the available satellite images and how different images may be combined. This work will be carriet out under supervision of the University of Iceland.

Methods for plotting ice charts based on observations will be improved, both at IMO and at Radiomidun (MaxSea).

QuickScat winds and validation of wind fields

QuickScat winds are an important addition to available information on wind in the data sparse area around Iceland. The wind information will be presented on maps in a form easy to interpret. Furthermore they will be used to monitor the reliability of wind forecasts calculated by numerical prediction models and should be helpful to indicate how the actual winds follow the model output. Maps of the difference between forecasted and observed winds will be produced and warnings may be issued when model and observations start to diverge.

Dangerous waves

Considerable value can be added to conventional wave forecasts by considering the likelyhood of dangerous breaking waves. A method has been developed by the Icelandic Maritime Administration to predict dangerous waves, based not only on the sea state but also on accident frequency and acceptable risk level.

Ice accretion on ships

Algorithms for warnings for risk of heavy ice accretion on ships will be investigated. The input will be fields from numerical prediction models, presumably wind speed, air temperature and sea surface temperature. Such warnings should be harmonised with other warnings, such as storm warnings.

Demonstrations

9.3 Plan for the MIO Viewer

Based on the experience obtained from the tests conducted by Kista Arctica during the summer 2001 intentions are to make an evaluation which will lead to adjustments and further development of functionality in the MIO Viewer. Furthermore, work will be initiated concerning the original ideas for extended functionality. In overall the issues which will be considered throughout the extended phase can be listed as:

- *Review and adjust existing functionality and interface components based on evaluation from tests in Greenland waters.* The response obtained from ship captains operating Kista Arctica will form the basis for adjustment of existing functionality. Furthermore, the design of the user interface will be reviewed and changes to interface components will be applied for improved user friendliness.

- *Re-factoring some of the basic code for better performance and for gaining more flexibility in relation to addition of new products.* The basic code will be reviewed and changes applied in order to improve performance. Furthermore, changes will be made to allow easier addition of new products, i.e. new meteorological or oceanographic parameters.

- *Implement functionality for viewing XML text messages.* As XML text messages is part of the IWICOS exchange formats, functionality for viewing these will be implemented. This will make it possible to view IMO's text based forecasts when operating Icelandic waters.

- *Automatic positioning of low and high pressure symbols.* GIS routines will be tried out in order to make an automatic positioning of low and high pressure symbols. This was an issue mentioned in the preliminary user response.

- *Implement a 'Statistics Module' for derivation of both temporal and spatial statistics.* One of the original ideas for the extended system was to implement a module for deriving statistics, e.g. concerning sea ice data. This concerns temporal aspects as well as spatial ones. Afterwards it will be possible to view the temporal development of ice concentration for a specific site, e.g. during the entire year or it will be possible to reveal the proportions that different ice classes make up for a user specified area.

- *Initiate work on a 'Route Condition Module' for describing conditions along predefined routes accounting for variations in time and space.* Here we will try to provide the user with met/ocean scenarios given a predefined route as input.

Some of the latter issues are quite ambitious and to what extent these will be accomplished is yet uncertain.

The demonstration

A demonstration of the MIO viewer will take place onboard one of the vessels of Royal Arctic Line during the spring/summer 2002. The demonstration will be carried out in Greenland and Icelandic waters, but the exact route(s) and vessel which will be used is yet uncertain.

9.4 Plan for the Baltic Sea

The following products are developed during the extended phase by the FIMR:

- **Improved SAR image classifications.** The existing operational RADARSAT image automatic classification algorithm shall be developed by adding inputs covering also ice history. A database including about 50 RADARSAT images has been analysed over the ice chart and high resolution grid information has been greated over ice concentration, minimum, average and maximum ice thickness and ice surface deformation degree. The database will be used in neural network classification development for RADARSAT SAR data in the Baltic Sea. Classifications will be made available operationally when RADARSAT SAR data are available.
- **Ice forecast presentation**. FIMR's JAAMA ice model will be improved reducing grid size from 18 km into 5 km. This is expecting to improve ice drift forecast for near-coast areas and narrow sea areas. As input forces HIRLAM wind forecasts for +48 h in 22 by 22 km grid will be used in combination of ECMFC +114 h in 40 by 40 km grid. Ice forecast will be run at least once a day, and send to users in digital maps and plain text.
- **Ice charts**. Finnish ice charts in will be made available once a day (appr. 11 GMT). On Mondays and Thursdays SST information are included in the charts.
- **Satellite images**. All useful sub-images of NOAA AVHRR will be made available for icebreakers and merchant vessels. Due restrictions in agreement between FIMR and RADARSAT International the RADARSAT SAR images will be made available only to the Finnish icebreakers.
- **Wave forecasts**. Improved wave forecasts (wind wave and swell direction and significant wave height) for next 48 h will be made available several times a day, in digital map format.
- **In situ water level data**. In situ water level data is made available several times a day, and presented within digital maps.

Demonstrations

The Finnish R/V Aranda is planned to make an expedition with about 25 scientist onboard to Fram Strate area next spring. The expedition is a candidate for demonstrations of extended IWICOS client in the Arctic. Planned time-table for expedition is 10 March - 1 May 2002. It will have two legs: the first leg for 6 weeks will take place in the Fram Strate area and it will be a joint effort of FIMR and Hamburg University. The second leg, which is still under planning and negation phase, will followed immediately in the Greenland Sea area lasting for 2-3 weeks. The Hamburg University is conducting the leg.

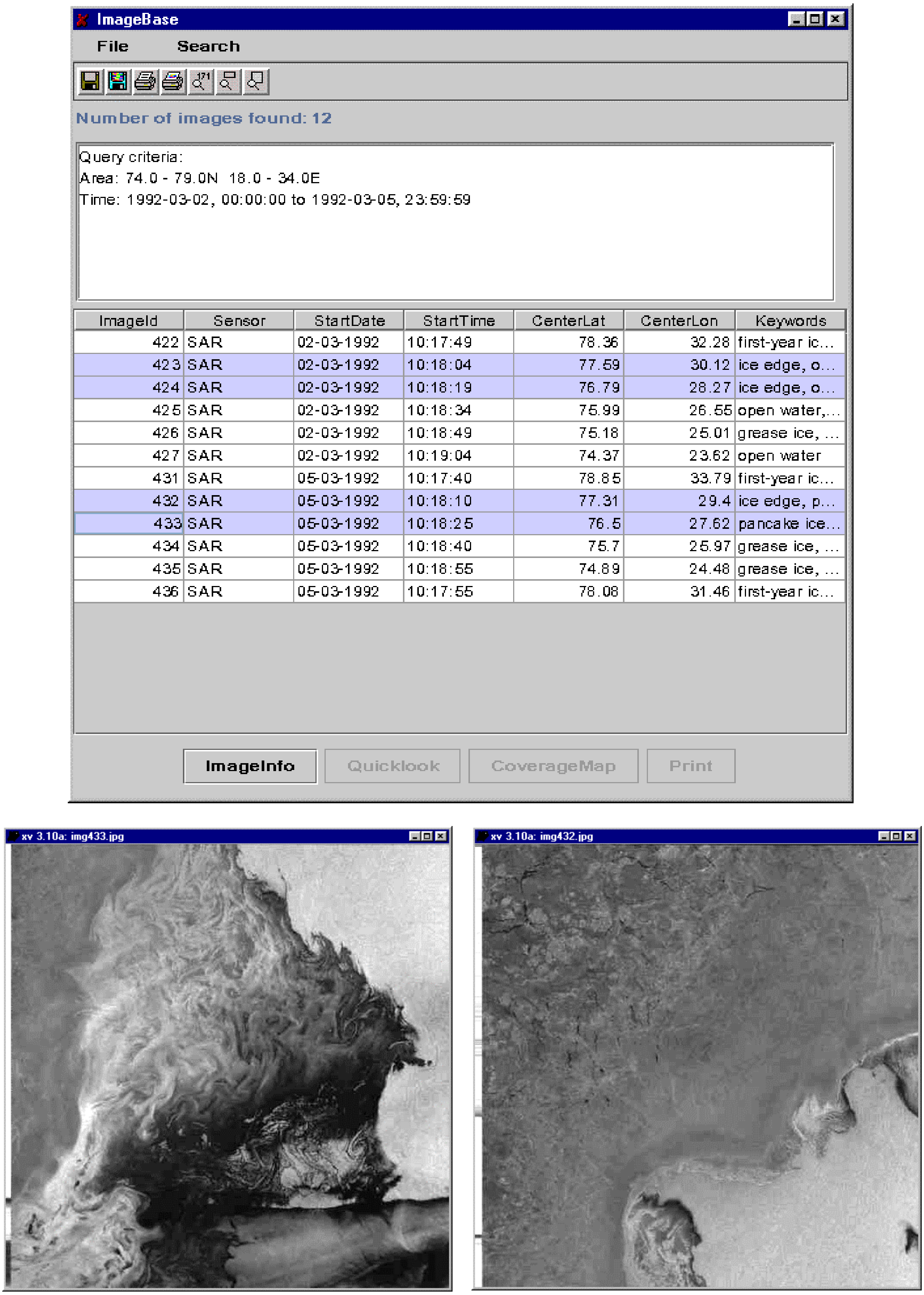
In the Baltic Sea the demonstrations must be held earlier than other areas, due to the ice season of the area. Planned period for extended demonstration is no later than February - March 2002. Users will be Finnish icebreakers and limited number of merchant vessels and shipbrokers.

9.5 Plans for Arctic services

9.5.1 SAR image archive of Arctic sea ice

The SAR ice client at NERSC will be further developed to include a) link to metadata generation programs; b) further investigate display of metadata; c) incorporate metadata for other types of products; and d) enable directory navigation

NERSC is building up a database of ERS and RADARSAT SAR images with quick-looks in JPEG format. The images are searchable via metadata including keywords as shown in Fig. 9.1. Examples of SAR quick-look images are also shown . This archive will be part of the extended IWICOS system.



ImageId	Sensor	StartDate	StartTime	CenterLat	CenterLon	Keywords
422	SAR	02-03-1992	10:17:49	78.36	32.28	first-year ic...
423	SAR	02-03-1992	10:18:04	77.59	30.12	ice edge, o...
424	SAR	02-03-1992	10:18:19	76.79	28.27	ice edge, o...
425	SAR	02-03-1992	10:18:34	75.99	26.55	open water,...
426	SAR	02-03-1992	10:18:49	75.18	25.01	grease ice, ...
427	SAR	02-03-1992	10:19:04	74.37	23.62	open water
431	SAR	05-03-1992	10:17:40	78.85	33.79	first-year ic...
432	SAR	05-03-1992	10:18:10	77.31	29.4	ice edge, p...
433	SAR	05-03-1992	10:18:25	76.5	27.62	pancake ice...
434	SAR	05-03-1992	10:18:40	75.7	25.97	grease ice, ...
435	SAR	05-03-1992	10:18:55	74.89	24.48	grease ice, ...
436	SAR	05-03-1992	10:17:55	78.08	31.46	first-year ic...

Fig. 9.1. Example of the NERSC SAR quick-look image archive.

9.5.2 The DTU/DVRS Java browser.

From user requests we intend to carry out the following enhancements to the end-user systems during the extended system phase:

- Easier access to data from previous days/months/years via navigation buttons.
- Access to ice model data
- Access to SST data
- Access to wave model data
- Improved colour manipulation control
- Parameter value (ice concentration, temperature, backscatter coefficient…) at the click of the mouse
- “Conditions along track” facility

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Appendix A: Summary of Questionnaire to the Users

To update the information regarding the capabilities at sea, a Questionnaire was sent to selected potential users in the Baltic Sea and for users in the Greenland Sea. The questionnaire indicates that E-Mail is used on almost all ships at the moment, and is estimated to be used 100% within two years. All ships have GSM-data, but this can be used only when the ship is within reach of the base station. For ships whose route is mainly in the Baltic sea , the time when out of reach is about 10 hours, for the passenger ferries even less than this, but in the Greenland Sea the ships are out of reach of the cellular phone system 95% of the time.

High speed satellite links at sea are still not common, but within 2 years of time a third of the ships in the shipping companies that replied to the questionnaire, will have a high speed link, either on permanent or on-demand basis.

The questionnaire and the answers are given below:

Questionnaire

Background:

IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres.
To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.

Date:		
Shipping Company/ or Name of ship:		
Sea area (Baltic Sea , Greenland Sea etc..):		
Size of the ship(s) (DWT):		
Type of ship(s):		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)		
2) E-mail on-board (store-and-forward connection)		
3) Other data service, what?		
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge		
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)		
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)		
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL		
e) GSM-data connection		
f) NMT with modem		
g) INMARSAT-C (with data communication ability)		
h) other data connection - what kind? (ORBCOMM etc..)		
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours:		
Other comments:		

THANK YOU FOR YOUR COOPERATION.
PLEASE RETURN THE QUESTIONNAIRE TO: Robin Berglund, VTT,
PB 1201, FIN-02044 VTT or FAX: +358 (0)9 456 6027 (or by E-mail to robin.berglund@vtt.fi)

Replies

Background: IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres. To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.		
Date: 7.5.2001		
Shipping Company/ or Name of ship: Finnlines plc		
Sea area (Baltic Sea , Greenland Sea etc..): Baltic		
Size of the ship(s) (DWT): 6000-15000		
Type of ship(s): RoRo, RoPax		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)	7	20
2) E-mail on-board (store-and-forward connection)	23	23
3) Other data service, what?	3	23
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge		
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)		2
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)		
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL	3	3
e) GSM-data connection	23	23
f) NMT with modem		
g) INMARSAT-C (with data communication ability)		
h) other data connection - what kind? (ORBCOMM etc..)		
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours: 10		
Other comments:		

Background: IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres. To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.		
Date:		
Shipping Company/ or Name of ship: Viking Line Abp (7 ships)		
Sea area (Baltic Sea , Greenland Sea etc..): Baltic		
Size of the ship(s) (DWT): about 10 000 - 45 000 (gross tonnage)		
Type of ship(s):): Ro-Ro passenger ferries		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)	6 of 7	Whole fleet
2) E-mail on-board (store-and-forward connection)	6 of 7	Whole fleet
3) Other data service, what?	On-line 24 h/day to shorebased network	
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge	6 of 7	Whole fleet
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)		
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)		
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL		
e) GSM-data connection	Whole fleet	Whole fleet
f) NMT with modem		
g) INMARSAT-C (with data communication ability)		
h) other data connection - what kind? (ORBCOMM etc..)		
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours: 10		
Other comments:		

Background:

IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres.

To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.

Date: 01. Feb. 2001

Shipping Company/ or Name of ship: Royal Arctic Line

Sea area (Baltic Sea , Greenland Sea etc..): Greenland Waters

Size of the ship(s) (DWT: 4990, 4523, 5817, 9556, 9556

Type of ship(s):): 4 containerships, 1 break bulk vessel

Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)	No	yes
2) E-mail on-board (store-and-forward connection)	Yes	yes
3) Other data service, what?	Skamlebæk radio (HF, Mufax)	
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge	No	no
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)	No	yes
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)	Yes (2 ships)	
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M)+EMAIL		
e) GSM-data connection	Yes	yes
f) NMT with modem	Yes	yes
g) INMARSAT-C (with data communication ability)	Yes	yes
h) other data connection - what kind? (ORBCOMM etc..)	INMARSAT-A (3 ships)	
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours:	95 % of the time	

Other comments: see next page

Data sent via	*Inmarsat*	*Mobile phone*	*VHF*	*HF*
Mufax	no	no	yes[1]	yes
Telefax	yes	yes[2]	yes[3]	no
email	yes	yes[2]	yes[3]	no

[1] Reception of Ice Charts as Mufax via VHF (Greenland VHF net) is possible, but requires special connection between Mufax and VHF.

[2] Reception radius is limited and determined by geographical position since antenna and mobile phone has to be within sight of one another. Furthermore a very stable connection is required.

[3] Reception is only possible coastwise and the connection has to be very stable. Thus it is not possible to maintain a stable connection where transmitters of VHF network overlap. Furthermore special equipment is required between VHF and Telefax and between VHF and computer.

NB: On the east coast of Greenland, the only option vessels have for receiving data is via Skamlebaek Radio (Denmark) as Mufax and, when situated below 70º N, through Inmarsat. Inmarsat guarantees communication up to 70º N although in reality it has shown possible to receive data up to app. 76º N. However the reception above 70º N depends on how stable the ship antenna is. This means that reception is weather dependant.

Appendix B: Response to the reviewer's comments after review meeting 30.01.01

Review of deliverables

D0: Project presentation

A project brochure has been prepared in glossy form for use in dissemination and marketing of the project. The draft was reviewed and discussed at the Midterm meeting.

D1: System design and user requirement document

An amendment document has been prepared which clarifies the questions raised by the reviewers (attached to this document).

D2: Dissemination and use plan

A new version of the Dissemination and Use Plan was discussed at the Midterm meeting where the reviewers' comments are taken into account. A market study has been carried out by IMO / Radiomidun and FIMR during the spring of 2001 as an extension of the user requirement analysis. The updated Dissemination and use plan and results of the market study are presented in D2 and D7-1.

D3.1 Annual progress report with evaluation and assessment

The reports on person-hour consumption has been improved as shown in the Quarterly reports no. 6 and so on.

Observations for future plans

The dissemination and marketing efforts are increased in year 2 compared to year 1, i.e. the market study carried out by IMO/FIMR and by presentation of IWICOS results in several conferences in 2001 - 2002.

The complementary role of the partners and improved focus on fewer products are clarified in the Amendment to D1 (attached to this document). The products can be classified in two categories: initial products and client products. Most of the envisaged baseline products are already being produced at the institutions involved as initial products, while several new client products have been developed.

Multi linguality and interoperability of the IWICOS system will be addressed by providing different languages in the user interfaces of the different systems (example:Swedish/English in the Baltic Sea). The symbols used in the presentation are multi-lingual as such. Information as Text is produced according to the language of the target groups (for example in Icelandic for Icelandic areas).

Brokering is better balanced with data supply/processing components compared to what was reported in D1.

Overall conclusions and recommendations

The next review meeting will be attended by more than only the coordinator. If we can combine a progress meeting one day with the review meeting the next day, all partners will be able to attend. This requires that the joint meeting can be scheduled 1 - 2 months in advance.

It is in all partners interest to have maximum synergy and complementarity of work. We believe that the project partners already work in a complementary way, but that this has not been clearly stated in the reports so far.

The e-commerce aspects will be addressed, especially on the provider side of the system.

More attention to dissemination, market analysis and business prospects has already been taken into account through dedicated activities in 2001. One subcontractor, Radiomidum, which is a private company doing business on providing information to fishing vessels, has been active in market analysis work in co-operation with IMO. FIMR has investigated the market in the Baltic Sea. A market study report is provided as deliverable D7-1.

Involvement of reference customers: we have a list of key customers who have helped us in the user requirement analysis and they will be used to test the system and give us feedback.

Standardisation aspects: this is a key issue in the IWICOS system. We have spent significant efforts on selecting standards for data and metadata (see D1).

Amendment to Deliverable D1

1. Treatment of redundant data

It is not obvious what the reviewers mean by redundant data in this project. We can interpret data redundancy in different ways:

a. several types of data are used to make a product, and all these data may not be necessary.

This is a normal procedure in operational services to ensure that several important data sources are available to guarantee that the products are of the best possible quality. Furthermore, the products which are delivered should not depend on one specific data source in cases when this data source fails.

b. similar products using the same type of data are developed in different regions, so why not have one product for all regions

Most products are specific for a region even if they are based on the same type of input data. In this project we are working in several regions with different met-ice-ocean conditions which require specific analysis and presentation techniques, driven by user requirements and operational practices. The project will however utilise possible synergy effects by using the same SSM/I algorithms for all regions, same SAR ice analysis methods, etc.

c. more than one partner work with development of the same product.

This is only done if it is necessary to adapt a product to different geographical regions. For example, SAR ice classification is developed by both NERSC and FIMR, but for different areas. It is not likely that the same method is applicable in the Baltic Sea and in the Arctic

d. several presentation methods can be used for the same product

Ice charts, for example, can be presented differently, but this is driven by user requirements, different standards etc.

2. Too many products

The term “product” has not been well defined yet and has therefore caused some confusion. It is necessary to classify the products into two categories:

1) **Initial products** are meteorological fields, satellite data, ice charts, oceanographical parameters, forecasting fields, etc. which already exist and are provided by the partners in various formats and layout. IWICOS will not be focussed on development of any new initial products, but use existing products as input to the client products. The initial products are well-defined and the formats are following the standard defined for IWICOS.

2) **Client products** are various new combinations and presentations of initial products which are specific for a given client. The number of client products is variable and dependent on what a user want to retrieve, especially for a thick client where the user can compose new products by himself. IWICOS product development is focussed on the client products

The number of initial products to be used and the number of client products to be developed within the project has been reduced compared to the project description. The number cannot be too low however, because IWICOS should demonstrate that the most important met-ice-ocean information can be presented and distributed via the end user systems under development.

The apparent high number of products does not necessarily give a correct picture of the situation. All the client data products come from a relatively small number of initial data products or data types (some types of satellite data, in situ data observations, meteorological fields, wave fields and other fields from atmospheric and ocean models). The number of client products becomes higher because there are different standards and techniques for presenting the same type of data. For example an ice chart for Greenland waters is presented in a different way compared to an ice chart in the Baltic Sea because there are different standards and agreements for producing official ice charts. Therefore, some products can be different technically, whereas their information content is similar. In IWICOS, we only need relatively few products to demonstrate the prototype system we are developing. On the other hand, with agreed standards for products and their metadata, it is easy to incorporate many different types of client products. One of the objectives of IWICOS is to allow a wide range of products to be accessible via the clients which constitute the end user systems.

3. Synergy and complementarity between the partners

The synergy between the partners can be described in terms of their different role and expertise as well as by the different geographical regions in which they work.

- DTU/DCRS: Daily ice concentration fields from SSM/I for specific regions as well as for the whole Arctic and Antarctica. In addition weather forecasts from NCEP are downloaded and prepared for access via DCRS' Internet browser. Additional weather forecasts can be delivered from DMI as needed by all partners. DTU/DCRS develops integrated products by combination of SSM/I and NCEP/DMI wind as well as other satellite data for distribution via their Internet browser (thin client). DTU/DCRS' primary role is, as research and development institution, to lead the development of the Java-based Internet service, which the other partners are using.
- DMI: producer of sea ice charts in the Greenland Sea based on NOAA AVHRR and RADARSAT SAR images. SSM/I data are used as supplementary information. Provider of weather forecasts for the Greenland areas as well as other areas as required by other partners. DMI develops integrated weather and ice chart products for the Greenland area based on a thick client solution. DMI has operational responsibility and delivers various products to users in the Greenland area.
- IMO: Provider of weather forecasts, waves and sea ice charts based on observations in the areas around Iceland. Textual information is provided in Icelandic and English. These products will also be used by DTU/ DCRS' Java-based service. IMO also uses the products delivered by DTU/DCRS and DMI in areas where IMO has responsibility for operational service. IMO works closely together with RADIOMIDUM in the distribution of products to end users
- RADIOMIDUM is a company which specialised on delivering information packages in digital form to fishing vessels. The company has developed a streamlined system called MaxSea which includes an end user system onboard vessels and communication with a database on land where weather forecasts and other met-ice-ocean products are stored.
- FIMR: provider of ice and ocean services in the Baltic Sea: ice charts in the winter season, sea surface temperature, water level data, wave data and forecasts. FIMR receives weather forecasts and other atmospheric information from Finnish Meteorological Institute and use this information as input to the ice and ocean services. FIMR develops new met-ice-ocean products for the Baltic Sea in close cooperation with VTT
- VTT: research institution which develops end user systems, communication solutions and new products which are used by FIMR and other operational services in the Baltic Sea. VTT has a key role in developing the common IWICOS modules which all partners are using.
- NERSC: research institution which develops various marine SAR application products, including a pilot system for SAR ice monitoring in the Arctic. SAR image quicklooks, with derived parameters (e.g. interpretation and/or ice motion). NERSC uses DTU's and DMI's products for the Arctic as a supplement to the SAR images.

4. Standards and modules in IWICOS

The focal point of the IWICOS project is the metadata standard and the broker which allow interoperability between different service providers and customers who wants to retrieve different products.

The metadata specification was developed by DMI, DTU and VTT based on the input provided by all partners. This specification has been developed by means of XML and XML Schema, both W3C standards. Metadata documents and example files have been distributed to all partners through the internal web site, enabling a detailed review of the specifications and check of compatibility with all baseline products. DMI have prepared the final metadata specification for the baseline system, rigorously documenting each metadata element and the relationship between them.

The IWICOS data formats have been defined to be BSQ, GRIB, Shapefile and XML. With XML both representation and presentation of data sets is more flexible. This allows a structure to be defined for the textual products and XML-related technologies such as XSLT (XSL - eXtensible Stylesheet Language, XSLT - XSL Tranformations) can be used to transform the data set to HTML that can be displayed directly in a web browser.

Another key element of the IWICOS system is the broker, currently denoted the baseline broker, and the software packages needed to use it. The broker is based on public domain software (web and servlet server from Apache, SOAP, Xerces, etc.) and uses standard HTTP for communication between the broker and the other system components (Producer Server and Facade). Documentation of the broker and links to software have been made available to all partners who have started to test it.

Based on the provided metadata search criteria, the broker will return an XML document, either a summary of matching fields for the query or the full metadata specification for the data sets satisfying the criteria. This enables flexibility in the way the broker can be used. Low bandwidth connections can request the matching fields mode, which will require small amounts of data to be sent between the system modules. High bandwidth connections can use the full metadata option since they are less concerned with the amount of data being transferred.

A Java applet is used to test the interface to the Broker, and a set of command line scripts are implemented to insert and manage the metadata for a new product and outdated products in the Broker database. Also a script. Also a script for retrieving the list of products delivered by a specific data-producer is produced. These test stubs and scripts are made available for the partners at VTT's broker web site.

All partners will use the metadata specification, the data formats and the broker when they build up their data provision services and products which are tailored for various types of users (i.e. thick, balanced and thin clients).

5. Restricted user group

A restricted user group has started to be formed. In Greenland, Kista Arctica of Royal Arctic Line has been used for the first testing of the baseline system presented by DMI, while in Baltic Sea several icebreaker captains have seen the first demonstration of baseline products developed by FIMR and VTT.

6. Clarify the role of the partners concerning the provision, treatment and brokerage of data.

As discussed above all partners have responsibility for provision and treatment of data, but in different regions and for different types of data. The broker software is developed and operated by VTT, while brokerage is done by each partner who is offering products.