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UPDATING THE ELECTRONIC CHART — THE SEATRANS PROJECT —

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Abstract

As a follow-up of the North Sea Project, which called for realistic tests of International Maritime Organization (IMO) Provisional Performance Standards (PPS) for Electronic Chart Display and Information System (ECDIS) systems and routines for chart updating, the Norwegian Hydrographic Service (NHS) is exercising a new venture known as the Seatrans Project during the spring and summer of 1990. The objective of the project is to test the first shipboard ECDIS which complies with the provisional IMO code in confined waters and under different weather conditions. The effect on workload and operational safety will also be analyzed and evaluated. The use of differential GPS (Global Positioning System) in the inner leads along the Norwegian coast will be examined by transmitting differential GPS corrections using existing radio beacons. Automatic and continuous updating of the Electronic Navigational Chart (ENC) using recommended satellite telecommunication will be undertaken and analyzed.

THE SEATRANS PROJECT

The 1987-built paper carrier NORNEWS EXPRESS operated by Seatrans ANS of Bergen, is furnished with a bridge arrangement prepared for one-man bridge operation in narrow waters. The vessel will sail a regular route between the ports of Skogn (near Trondheim) and Oslo, Hamburg and Amsterdam using the Disc Navigation ECDIS system which is being developed further by The Norwegian Marine Technology Research Institute (Marintek A/S) to comply with IMO PPS (Fig. 1). The classification society Det norske Veritas (DnV) and the Norwegian Maritime Directorate will specify the system — and testprogram requirements — and conduct the evaluation of the seatrial results. The NHS will provide authorized digital data of an adequate quality for ECDIS-systems including colorfill, and be responsible for automatic and continuous transmission of chart corrections using INMARSAT C satellite communication.

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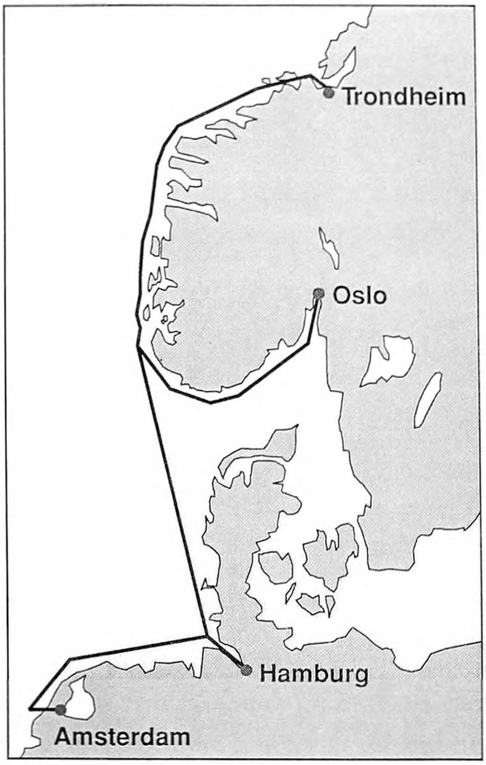

FIG. 1.— Route covered by the vessel NORNEWS EXPRESS.

DATABASE STRUCTURE

A total of 35 charts along the 1 000-nautical mile route have to be digitized and processed. The NHS has developed routines for automatic generation of area definitions which provide for colorfill along the route. This results in an extensive amount of digital chart data which has to be organized and stored in an efficient way. The NHS will be using their in-house Electronic Navigational Chart Database (ENCDB) system developed for the North Sea Project in the Seatrans Project. It has been developed further to optimize operation and extend its functionality to achieve improved efficiency.

The ENCDB has been designed in compliance with IHO Special Publication No. 52 (SP-52). It also incorporates the global cell numbering system set forward in SP-52. The database is divided into four modules (Fig. 2). The APPR part contains approved and validated digital source data. The MOD part contains modifications or corrections to the source data. The ADM part stores some administrative information to control and ensure consistent operation of the database. Light information is stored in special nationality cells in the ADM part to reduce the processing complexity since light sectors may span the boundaries of a single cell. The SATCOMM part controls and administers the transmission of chart corrections.

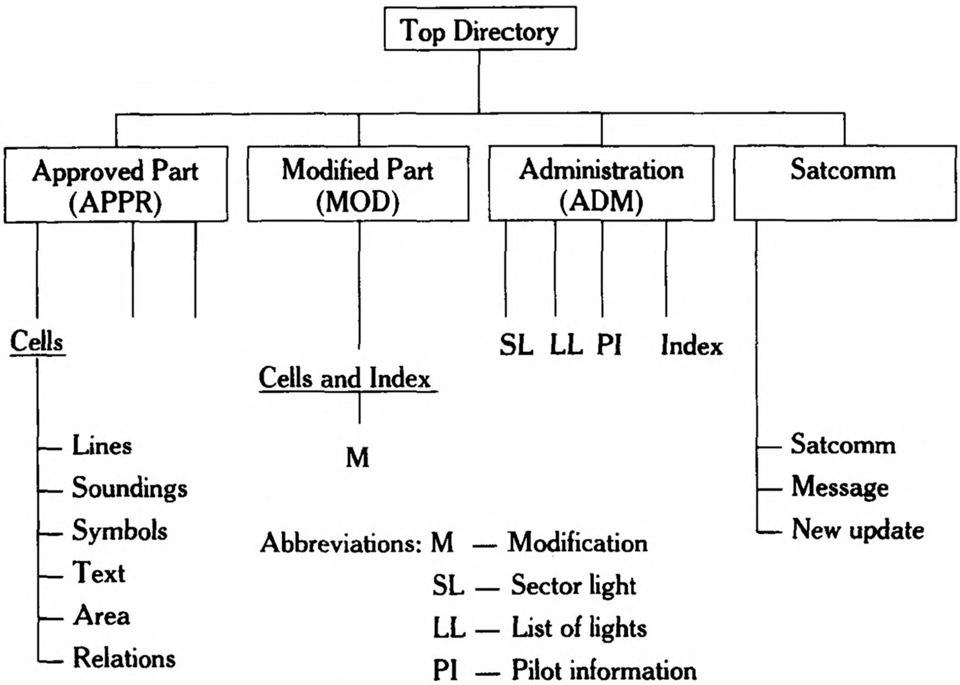

FIG. 2.— Overview of the ENCDB database structure used at NHS.

The APPR and MOD parts are further divided into cell directories. For each source cell defined in APPR, a corresponding modification cell is defined in MOD. Each cell directory in the APPR part contains a set of tables to store the information — one table for each class of objects e.g. lines, areas, soundings etc. Each cell directory in the MOD part contains a table to store chart corrections recorded for each cell.

INMARSAT C SYSTEM

INMARSAT (INternational MARitime SATellite orgnization) is operating an international satellite system in cooperation with national teleadministrations in member countries. The satellites have a global coverage between 70°N and 70°S which excludes the extreme polar areas. The satellites are operating 24 hours a day. INMARSAT operates several communication systems distinguished by functionality, cost and communication services. Today, the INMARSAT A and INMARSAT C systems are available, while INMARSAT B and INMARSAT M will become available in the future (1993).

The primary function of INMARSAT C was to provide text and data transmission to and from ships and terrestrial subscribers in a compact and cost-effective way without reducing the quality. INMARSAT C transmissions operate at an information rate of 600 bits/sec. An INMARSAT C Ship Earth Station

(SES) receiver is a data/text terminal consisting of a small omnidirectional antenna and an Electronic Unit (EU) the size of a large book. A regular Personal Computer (PC) is connected to the EU and handles the receipt and transmission of messages.

Several services are available in INMARSAT C — EGC (Enhanced Group Call), GMDSS (Global Maritime Distress and Safety System), SafetyNET and FleetNET. In EGC, messages can be sent to group(s) of ships (group call) or to geographic areas (area call). Several services for special purposes are dedicated in the EGC, e.g. chart updating (service code = 72) or weather forecast. This chart updating service will be employed in the Seatrans Project for transmission of chart corrections.

DEVELOPMENT OF A CHART CORRECTION FORMAT

To support the realistic and real-time testing of automatic chart updating desired in the project, the cooperating industry and NHS early realized the necessity and importance of a chart correction format. Since no format was internationally approved or in the process of being developed, the NHS developed a chart correction format to be used in the project and for future testing and applications. It was also apparent that this effort could provide valuable response and contributions to the development and acceptance of Electronic Navigational Charts (ENC) and ENCDB's.

The following list of directions was prepared and followed during the definition of the chart correction format:

- be system, design and manufacture independent
- be compact and efficient, and hence cost-effective
- be consistent and maintain data integrity.

It was also noted that INMARSAT already has allotted a dedicated function in the Enhanced Group Call service (EGC) for transmission of chart correction messages.

The format was designed to be and remain consistent from the point of view of the Hydrographic Offices (HO) and the users of the data, e.g. ECDIS manufacturers. The database structure and systems used at Hydrographic Offices and in ECDIS systems are currently and will in the future be different and more or less incompatible. The format was consequently designed to not reflect or conceal information about the database structure being used at NHS, but only to provide necessary geographical information for chart updating.

The format was also designed to be compact and cost-effective to maintain system efficiency. The format could be made very compact and simple by using the assigned ID (Identification Number) on each chart object stored in the database to uniquely identify an object in a message. This method was rejected because it would put constraints on ECDIS manufacturers in respect to system implementation. But the format was still able to be compact by using only a feature code together with x and y positions to uniquely identify a chart object.

The DX90 is a format designed to represent geographical information not to be used as a communication format in a compact and cost-effective way. The DX90 breaks all compound objects down into their smallest definable objects with a varying number of attributes, e.g. a lateral buoy and a topmark consist of 17 attributes each. No complex objects (defined by two or more compound objects) have been defined. The DX90 is hence quite inappropriate to be used as update format since you have to specify for example 34 attributes to update a lateral buoy with a topmark.

MESSAGE TYPES

Several different communication protocols are defined in the format to provide broadcast services of chart correction messages from NHS to vessels and the ability of vessels to request chart correction information automatically from the ENCDB at NHS. The latter protocols were included because it is possible that vessels may lose some of the chart correction messages, e.g. while a vessel is operating outside the coverage of INMARSAT C or is in a dry-dock.

The following message types have been defined:

- General chart correction message. This is general chart corrections messages broadcasted to all vessels.
- Specific chart correction message. A vessel might request retransmission of one or more chart correction messages it has lost. This is the answer to the request and contains chart corrections transmitted only to the requesting vessel.
- Historical account of all chart corrections in a cell. This message contains a historical account of all chart corrections registered in a cell and is transmitted only to the vessel making the request.
- Historical account of all chart corrections in a geographical area. This message contains a historical account of all chart corrections registered in a geographical area specified by the requesting vessel. This message-type is different from the above because the area can be larger than the size of a cell and it includes information from all chart layers (scales) in the requested area.
- Historical account of all chart corrections in a time-period. This message contains a historical account of all chart corrections registered in a time-period requested by a vessel.
- Message size warnings. Since it is possible that a vessel deliberately or by an error might request a huge amount of information which would result in extensive communication costs, a warning will be transmitted if the answer message from NHS is larger than a predefined size (will be determined when transmission costs are known). The vessel must then acknowledge if it still wants to have the message transmitted.
- Error message. Each request from all vessels is checked for possible errors and an appropriate error message is transmitted to the vessel when applicable.

GENERAL OUTLINE OF A CHART CORRECTION MESSAGE

All chart correction messages are divided in some distinct blocks (Fig. 3). The start code indicates the start of the chart correction message. The header block contains some administrative information regarding the correction, e.g. the unique correction ID, duration, etc. The data block contains the physical correction. The end code indicates end of message. A checksum has been added because the INMARSAT C EGC service does not provide adequate error checking facilities. However, regular INMARSAT C communication (standard C) provides sufficient error checking.

Startcode
Header
Data

Header
Data
Endcode, checksum

FIG. 3.— *Message containing two chart corrections.*

Below is a typical correction message outlined with an explanation of all the fields involved. The example depicts the insertion of a new depth value.

Startblock	
Startflag: *	— Indicates start of message
Broadcaster: A	— A = Norwegian Hydrographic Service
Message type: 0	— Message is a general chart correction
Headerblock	
Nationality code: N	— The next three fields is a reference to
Journal No. NtM: 213	message 213 in the printed Norwegian
Year: 89	Notice to Mariners 1989
Correction ID: 325	— Unique ID of correction message
Cell: B5680016	— Name of cell correction is applied to
Valid from: 890214	— Time period correction is valid.
Duration: 901224	The duration field is optional
Datablock (sounding)	
Modification type: I	— A new sounding is inserted
Feature code: 500010	— NHS feature code for soundings
Z: 120	— Depth
Y: 552334.12	— Y-position
X: 41233.46	— X-position
Endcode	
Endflag: *	— End of message
Checksum: 213	— Checksum for message

This results in the following message being transmitted to the vessels:

```
*A0
N,213,89,325,B5680016,890214,901224
I,500010,120,552334.12,41233.46
*,213
```

The correction ID is an unique consecutive number assigned to identify and distinguish each message from each other. The vessels can use this number to determine if they have lost a message. By the fact that this number is consecutive and a vessel for example already has received message 323 and now receives message 325, the ECDIS system immediately knows it has lost message 324 and can make a request to NHS for retransmission of message 324.

Three types of modifications can be applied to a chart cell. An object can be **inserted, deleted** or **replaced.** These operations are distinguished with the letters I, D and R. In the case of replace corrections, some additional fields (for soundings Old Z, Old Y and Old X) are supplied to identify the old object to be replaced.

It is estimated in the report delivered by the IHO/COE Working Group on Updating the Electronic Chart that 135 Kbytes of information have to be transmitted weekly for automatic updating worldwide. In the calculations, the working group estimated the size of overhead information associated with a chart correction to be ten times the basic information. But in the format developed at NHS, the overhead information is considerably lower.

UPDATING RESPONSIBILITIES

The correction message initiated at the NHS has a long voyage through space and different technical systems before it appears on the Electronic Navigational Chart. All modules involved in the transmission of messages in the Seatrans Project is depicted in Figure 4.

The NHS is responsible for generating the chart correction message and transmit it on the public telex network to an INMARSAT Coast Earth Station (CES). The INMARSAT CES receives the message and stores it until a space segment becomes available ('store and forward' technique). The message is then broadcasted through space to the vessel(s). An INMARSAT C Ship Earth Station (SES) aboard the vessel receives and processes the message. The Saturn C SES receiver from EB Nera will be used in the Seatrans Project. The Saturn C contains software which automatically detects and transfers the incoming chart correction mesage on a local area network (LAN) to the Disc Navigation ECDIS system. The Disc Navigation ECDIS system is then able to automatically update the Electronic Navigational Chart.

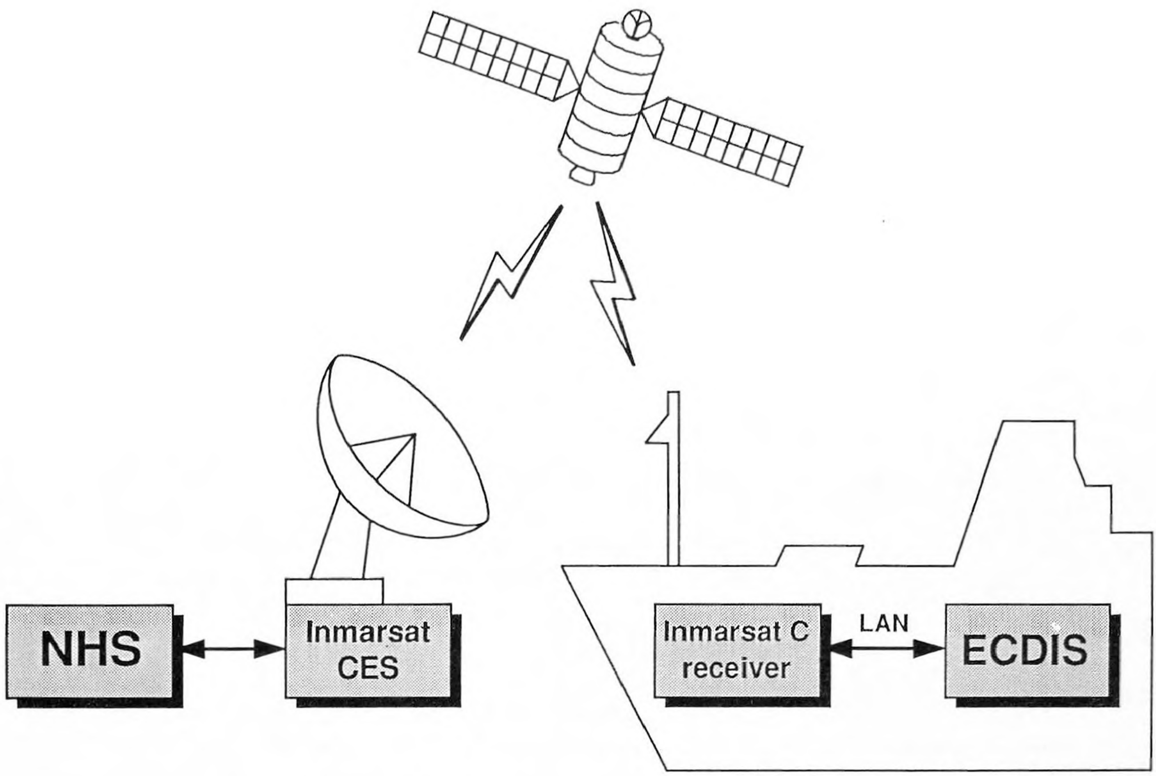

FIG. 4.— Information flow and responsibilities in the Seatrans Project.

NHSs ADMINISTERING OF CHART CORRECTIONS

All chart corrections occurring during the Seatrans Project are entered on an in-house developed chart editing software package running on a PC-compatible 386 computer. The operator views a chart cell on the computer display and can with a mouse pointing device manually enter the chart corrections. These chart corrections are then transferred to the ENCDB and stored in the MOD-part. A satellite communication software package is able to automatically detect the arrival of new chart corrections entering the ENCDB. This program prepares and formats the message and broadcasts it to the vessels using INMARSAT C chart correction EGC service. As a follow-up of the Seatrans Project, solutions for a direct communication link between the national chart maintenance database and the Electronic Navigational Chart database will be investigated and established.

All incoming request messages from vessels reach NHS on the public telex network. The telex machine is able to distinguish between regular telex messages and requests from vessels because of the nature of the request codes specified in the format. All requests are routed to the satellite communication software package which automatically detects all incoming requests. The requests are processed and the appropriate answers are transmitted using INMARSAT C.

The satellite communication software runs 24 hours a day and keeps a log of all transactions executed. A list of all messages transmitted and a log of the recipients are also kept in the database for future analysis and use, e.g. billing. All errors encountered during system operations is flagged to the user and also kept in an error log. A typical user interface for the program is shown in Figure 5.

12-feb-90 12:34:45	Satcomm program started
12-feb-90 14:00:11	Message prepared for transmission
12-feb-90 14:00:12	Message prepared for transmission
12-feb-90 14:00:12	Message successfully transmitted
13-feb-90 17:25:37	Request received from vessel
13-feb-90 17:25:37	Error in request
13-feb-90 17:25:38	Error message transmitted
14-feb-90 23:12:47	Request received from vessel
14-feb-90 23:12:48	Req. processed and succ. transmitted
17-feb-90 16:00:00	Satcomm program stopped

FIG. 5.— Typical user interface for Satcomm-program. The user can examine the error log to determine the cause of the error.

CONCLUSIONS

The Seatrans Project is perhaps the first realistic exercise of Electronic Navigational Charts (ENC) and chart updating using recommended procedures and an ECDIS system complying to the provisional IMO code. Several activities related to the future use of ENC will be tested and evaluated. The NHS hopes the Seatrans Project will make a contribution to developing the broader North Sea model ENCDB and speed up the Hydrographic Offices ability to deliver digital chart information of an adequate quality.

Acknowledgement

Mr. Per Arvid Jakobsen, Norwegian Hydrographic Service.

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[5] Special Publication No. 52 (SP-52). International Hydrographic Organization.

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