

**THE IMPLEMENTATION OF THE INTERNATIONAL
HYDROGRAPHIC ORGANISATION'S WORLDWIDE
ELECTRONIC NAVIGATIONAL CHART DATA BASE
FOR ELECTRONIC CHART DISPLAY AND
INFORMATION SYSTEMS**

THE IMPLICATIONS TO SUB-SAHARAN AFRICA

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We cannot discover the oceans unless we have courage to lose sight of the shore.

Anon.



SYNOPSIS

This report gives suggestions to sub-Saharan Africa regarding the implementation of the International Hydrographic Organisation's (IHO) Worldwide Electronic Navigational Chart Data Base (WEND) for Electronic Chart Display and Information Systems (ECDIS). The IHO, recognising the need to supply up-to-date navigational information to mariners at sea, proposes the establishment of a worldwide network of navigational information. This proposal is aimed at addressing the information needs of international shipping. However, it does not restrict any hydrographic office from developing its own data base for national shipping.

ECDIS is one new technology that will improve safety at sea. It integrates the Electronic Navigational Chart (ENC) and other navigational information. Unlike the paper chart, ECDIS will select and display information that is needed at any chosen moment thereby removing clutter from the display. The mariner will only see the information that is relevant for his immediate decision-making. ECDIS is versatile, complex and a potentially important aid to navigation decision-making. It enables mariners to navigate under conditions of poor visibility and through narrow and poorly-marked channels. It has the power to process data from a variety of sources and to detect and graphically show relationships between the data.

Since history requires us to look at the past and the present to be able to project into the future, the report begins by giving the background to electronic charts. The report examines the traditional paper chart and the present method of updating the chart. It looks at the information contained in the Notices to Mariners, Radio Navigational Warnings and Global Maritime Distress and Safety Systems. The responsibilities and obligations of the various professional disciplines involved in updating the paper chart are also discussed. The limitations of the paper chart is commented upon and the need for a new technology is emphasized. The procedure for updating the electronic chart is

also discussed. The terms "paper chart" and "traditional paper chart" are used interchangeably and mean the same thing in this report.

The second chapter examines the requirements of ECDIS. It discusses the user requirements and the minimum system configuration. Operational and performance requirements are also examined.

Chapter Three discusses the Worldwide Electronic Navigational Chart Data Base (WEND). It gives a brief background to WEND and discusses the conceptual model of the organisation of WEND on regional bases. It examines a paper presented by Australia in relation to a single state WEND proposed by Norway.

Since the whole process of networking the navigational information depends on technology, an in-depth treatment of the subject is carried out in Chapter Four. Issues discussed include networking and distributed system, standards and protocols in telecommunications.

The design consideration for the infrastructure for a Regional Electronic Navigational Chart Coordinating Centre (RECC) is dealt with in Chapter Five. Financial and institutional issues are discussed. Technical and non-technical security measure are commented upon.

Chapter Six deals with the infrastructure design for a RECC. It examines the infrastructure components, system operation and maintenance and manpower.

Strategies for implementing RECC in the sub-Saharan Africa are discussed in Chapter Seven. Network development, data and system security measures are commented upon.

Chapter Eight looks at the legal implications of ECDIS and WEND. It examines the elements of the legal regime and speculates on the possible changes that could be brought about as a result of the changing technology.

Chapter Nine concludes the report with recommendations on a regional WEND centre.

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LIST OF ABBREVIATIONS

ARPA	:	Automatic Radar Plotting Aid
ANM	:	Automatic Notices to Mariners
CD	:	Compact Disk
COE	:	Committee on ECDIS
CEDD	:	Committee on Exchange of Digital Data
CPU	:	Central Procession Unit
DDBMS	:	Distributed Data Base Management Systems
DGPS	:	Differential GPS
DMI	:	Directory of Marine Information
EC	:	Electronic Chart
ECS	:	Electronic Chart Systems
ECDB	:	Electronic Chart Data Base
ECDIS	:	Electronic Chart Display and Information Systems
ENC	:	Electronic Navigational Chart
ENCD	:	Electronic Navigational Chart Data
ENCDB	:	Electronic Navigational Chart Data Base
EGC	:	Enhanced Group Call
GIS	:	Geographical Information System
GMDSS	:	Global Maritime Distress and Safety System
GPS	:	Global Positioning System
HO	:	Hydrographic Office
IHO	:	International Hydrographic Organisation
IHB	:	International Hydrographic Bureau
IHC	:	International Hydrographic Conference
IHR	:	International Hydrographic Review
ISDN	:	Integrated Services Digital Network
IMO	:	International Maritime Organisation
INMARSAT	:	International Maritime Satellite Organisation
LAN	:	Local Area Network
MAN	:	Metropolitan Area Network
MSI	:	Maritime Safety Information
NtM	:	Notices to Mariners
OSIE	:	Open Systems Interconnection Environment
PS	:	Performance Standard

PSDN	:	Public Switch Data Network
RECC	:	Regional ENC Coordinating Centre
RTCM	:	Radio Technical Commission for Maritime Services
SOLAS	:	Safety of Life at Sea
SENC	:	System Electronic Navigational Chart
S-52	:	IHO Special Publication 52 (Provisional Specifications for Chart Content and Display Aspects of ECDIS)
WAN	:	Wide Area Network
WEND	:	Worldwide Electronic Navigational Chart Data Base
WWNWS	:	World Wide Navigational Warning System

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GLOSSARY AND ACRONYMS

Unless otherwise stated the glossary and acronyms below were obtained from the Glossary of ECDIS-Related Terms (IHO, 1993).

ACCURACY : The extent to which a measured or enumerated value agrees with the assumed or accepted value. Not to be confused with precision.

AIDS TO NAVIGATION: Visual, acoustical or radio device external to a craft designed to assist in the determination of a safe course or of a vessel's position, or to warn of dangers and obstructions.

ALARM : Audible or visual means of announcing a condition requiring attention.

ALL OTHER INFORMATION : Term used in the Draft Performance Standard for ECDIS to describe information not belonging to the Standard Display. Also sometimes called " on-demand information".

AUTOMATIC CHART CORRECTION: A correction applied to an ENC in a machine readable form so that no operator interaction is involved.

AUTOMATIC RADAR PLOTTING AID(ARPA): A system wherein radar targets are automatically acquired and tracked and collision situations computer-assessed and warnings given.

CELL UPDATE: An updating method by which the content of an entire cell is replaced by new data.

CELL(CHART CELL): Pre-defined, scale-dependant geographic area.

CHART SYMBOL: A character, letter, line style, or similar graphic representation used on a chart to indicate some object, characteristics, etc.

CHART INFORMATION: HO-information relevant to navigation contained in nautical chart.

CHART(NAUTICAL): A chart specifically designed to meet the requirements of marine navigation, showing depths of water, nature of bottom, elevations, configuration and characteristics of coast, dangers and aids to navigation.

The carriage of up-to-date charts (plus certain other nautical publications) by vessels at sea is a mandatory requirement of SOLAS regulation V 20.

CHARTLET: A small auxiliary chart giving new details on a particular area, to be added to the chart after publication. Also called block correction or chart amendment patch.

COASTAL WARNING: A navigational warning promulgated by a national co-ordinator covering a coastal or a portion thereof.

COMMITTEE ON EXCHANGE OF DIGITAL DATA (CEDD) : IHO Committee tasked with the development and coordination of a standard digital exchange format.

COMMITTEE ON ECDIS (COE) : A committee of the IHO responsible for ECDIS matters works in close relationship with the CEDD and the CSC (Chart Specifications Committee). Conducts work through several specialist working groups, including the Group of Experts dealing with specifications, and the WG on Updating ECDIS.

DATA BASE : An organized, integrated collection of data stored so as to be capable of use by relevant applications with the data being accessed by different logical paths. Theoretically it is application-independent but in reality it is rarely so.

DATA STRUCTURE: A specification of the logical organisation of the components of a data model and the manner in which relationships among components are to be explicitly defined.

DATA MODEL: A conceptual specification of the sets of components and the relationships among the components pertaining to the specific phenomena defined by the model reality. A data model is independent of specific systems or data structure.

DATA: A representation of facts, concepts or instructions in a formalised manner suitable for communication, interpretation or processing.

DATUM: vertical. A surface to which elevation and / or depths (soundings and tide heights) are referred. For elevations commonly a level (equipotential) surface, approximating to mean sea level is used, for depths in many cases low water. Also called chart datum, datum level, datum plane, reference level, reference plane.

DATUM: A set of parameters specifying the reference surface coordinate system used for geodetic control in calculation of coordinates of points on the earth. Commonly datums are defined as horizontal and vertical datums separately. For the practical use of the datum it is necessary to have one or more well monumented points with coordinates given in that datum.

DATUM: horizontal. A set of parameters specifying the reference for horizontal geodetic control, commonly the dimension and the location of a reference ellipsoid. At least five quantities are required: the semi-major axis a , the flattening f , and the coordinates ϕ , λ , h of an initial point. Absolute datums specify the centre of the reference ellipsoid to be (ideally) located at the earth's centre of mass. In modern reference systems especially those with datum information given by satellite orbits (e.g. WGS 84) additional parameters are defined, e.g. gravity models.

DIFFERENTIAL GPS (DGPS): A form of GPS in which the reliability and accuracy are enhanced by broadcasting a time-varying correction message from a GPS monitoring receiver (Differential Model) at a known position on shore. The corrections are fed automatically to the GPS receiver on board and used to compute an improved position.

DIGITIZATION (digitisation): The process of converting analog data to digital data.

DIRECTORY : Defines the contents of the transfer in terms of the included modules, specifies how to access individual modules, and specifies the relationships between modules. It also relates modules to spatial domains. It therefore describes the physical, logical and spatial organization of the transfer at the module level.

DIRECTORY OF MARINE INFORMATION : A directory containing a list of countries contributing data to the RECC, geographical area of the data coverage, scale of charts, category of navigational information, policy on data exchange etc. (Writer's definition).

DISPLAY BASE: The level of SENC information which cannot be removed from display, consisting of information which is required at all times in all geographic areas and all circumstances. It is not intended to be sufficient for safe navigation.

DISPLAY: A visual presentation of data (eg a line of alphanumeric data, a window, or the entire screen).

DX90-FORMAT: Format for the encoding or interchange of digital cartographic data developed by CEDD. DX90 is part B of the IHO Transfer Standard for Digital Hydrographic Data (S-57).

ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS) : A navigation information system which can be accepted as complying with the up-to-date chart required by regulation V/20 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigation chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and if required display additional navigation-related information.

ELECTRONIC NAVIGATIONAL CHART DATA (ENCD): The national data for an Electronic Navigational Chart (ENC) in a format acceptable to an ENC Coordinator.

ELECTRONIC NAVIGATIONAL CHART DATA BASE (ENCDB): The master data base for production and maintenance of the ENC, compiled from national ENC data (ENCD).

ELECTRONIC CHART SYSTEM (ECS): Generic term for equipment which displays chart but which is not intended to comply with the IMO Performance Standard for ECDIS. ECS is intended for use in conjunction with a paper chart.

ELECTRONIC CHART DATA BASE (ECDB) : The master data base for Electronic Navigation Chart Data (ENCD), held in digital form by the national hydrographic authority, containing chart information and other nautical and hydrographic information.

ELECTRONIC CHART : An integrated, interactive, navigation information system, with which the user can display the hydrographic and positional information that is required to conduct the safe navigation of his vessel. It comprises hydrographic and cartographic data bases containing information useful for navigation.

ELECTRONIC NAVIGATIONAL CHART(ENC) : 1. An electronic navigational chart is a subset of the electronic chart data base held on the vessel. It contains information on features useful for navigation such as coastline, obstructions, beacons etc.

2. The data base, standardized as to content, structure and format, issued for use with ECDIS. The ENC is equivalent to the new edition of the paper charts, and may contain additional supplemental nautical information.

ENHANCED GROUP CALL (EGC): A global automatic service by INMARSAT for addressing commercial messages(FleetNet) or marine safety information(MSI) (SafetyNet) to groups or ships or all vessels in both fixed and variable geographical areas. Data transmission is based on INMARSAT Standard-C and takes place at an effective transmission rate of 600 bits/s.

EXCHANGE FORMAT: A specification for the structure and organization of data to facilitate exchange between computer system.

FILE : A collection of data for a specific task or purpose stored on a mass storage device.

FLEETNET: An INMARSAT EGC service, providing a commercial service for national and company fleet group calls, and the possibility of subscription services for news, stock exchange information, fish landing prices, etc.

GENERALISATION : The selection and or omission of less important detail for presentation of features at an appropriate scale. Its purpose is to avoid congestion on charts/maps where space is limited

GEOGRAPHIC INFORMATION SYSTEM (GIS) : A system for storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the earth. This is normally considered to involve a spatially referenced computer data base and appropriate applications software.

GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM: The communication service, co-ordinated worldwide, comprising functions which include among others, the:

- dissemination of marine safety information: broadcast of navigational and meteorological warnings, Notices to Mariners, and urgent information to shipping;
- general radio communications: those communications between ship station and shore-based communication networks which concern the management of the ship and may have an impact on its safety, and
- bridge-to-bridge communications: inter-ship VHF radiotelephone communications for the purpose of assisting the safe movement of the ship.

HARDWARE : All physical material components of a computer system as e.g. central processing unit (CPU), peripheral devices etc. May also include individual chips.

HARMONIZATION GROUP ON ECDIS (HGE) : Joint Working Group of IMO and IHO tasked to develop the performance standard for ECDIS.

INFORMATION : Intelligent resulting from the assembly, analysis or summary of data into a meaningful form.

INMARSAT : International Maritime Satellite Organisation, an international consortium which provides worldwide satellite communications links to ships at sea.

INTERNATIONAL MARITIME SATELLITE ORGANISATION: An international consortium which provides worldwide satellite communication links to ships at sea.

ISSUING AUTHORITY : The official agency which issues the ENC and ENC updates. Its identity will depend on the organisational structure adopted for ECDIS support.

INTERNATIONAL HYDROGRAPHIC BUREAU : Founded in 1921 in the Principality of Monaco, to establish a close and permanent association among the hydrographic offices of its Member States; since 1970 the headquarters of the IHO. (Hydrographic Dictionary, 1990)

INTERNATIONAL HYDROGRAPHIC ORGANISATION (IHO) : Coordinates the activities of national hydrographic offices; promotes standards and provides advice to developing countries in the fields of hydrographic surveying and production of nautical charts and publications.

INTERNATIONAL MARITIME ORGANISATION (IMO) : Formally called IMCO, the IMO is the specialized agency of the United Nations responsible for maritime safety and efficiency of navigation.

LIST OF LIGHTS : A publication tabulating navigational lights, with their locations, candle power, characteristics, etc. to assist in their identification, and details of any accompanying fog signal. A list of lights may contain other information useful to a navigator. Also called light list.

MARITIME SAFETY INFORMATION : Navigational and meteorological warnings, Notices to Mariners, meteorological forecasts, and other urgent safety messages.

MEMBER STATES : States or countries in sub-Saharan Africa that are members of the IHO and those with observer status (Writer's definition for the purpose of this report).

MINIMUM CONTENT : The minimum content of HO-data to be stored in the ENC, i.e. the data needed to produce the Standard Display plus All Other Chart Information. This will contain at least the same information relevant to safe navigation as is at present on the paper chart.

NAVAREA : A geographical sea area established for the purpose of co-ordinating the transmission of long range Radio Navigational Warnings.

NAVAREA WARNING : A navigational warning issued by the NAVAREA co-ordinator for the NAVAREA.

NAVIGATION AID : Any instrument, device, chart, method, etc., used on board intended to assist in the navigation of a craft.

NAVIGATIONAL WARNING : A broadcast message containing urgent information relevant to safe navigation.

NAVINFONET : Navigational Information Network - A US (DMA) automated service for providing Notice to Mariners and other safety information via digital link at user request.

NAVTEX : Narrow-band direct-printing telegraphy system for transmission of navigational and meteorological warnings and urgent information to ships.

NORTH-UP DISPLAY : The information is shown on the display (radar or ECDIS) always with the north direction upwards. Corresponds to the orientation of the nautical charts but differs usually from the view from the ship's bridge in the direction of the ship's heading.

NOTICES TO MARINERS : A periodical or casual notice issued by hydrographic offices, or other competent authorities, regarding changes in aids to navigation, dangers to navigation, important new soundings, and, in general, all such information as affects nautical charts, sailing directions, light lists and other nautical publications.

OWN SHIP'S SYMBOL : A non-chart symbol used in ARPA and ECDIS to show the ship's position on the chart or ARPA display.

OWN SHIP : The term which identifies the vessel upon which an ECDIS is operating.

OWN SHIP'S SAFETY CONTOUR : The contour related to the own ship selected by the ship's master out of the contours provided for in the SENC, to be used by ECDIS to distinguish on the display between the safe and the unsafe water, and for generating anti-grounding alarms.

PERFORMANCE STANDARD : Standard developed under the authority of IMO to describe the minimum performance requirements for navigational devices and other fittings required by the SOLAS Convention.

PIXEL : Contraction for "picture element". The smallest element resolvable by electronic raster devices such as scanner, display and plotter.

PRECISION : The degree of refinement of a value. Not to be confused with accuracy.

PRESENTATION : Cartographic design including drawing, use of symbols, use of colours, use of conventional practices, etc.

PRESENTATION LIBRARY : A set of mostly digital specifications, composed of symbol libraries, colour schemes, look-up tables and rules, linking every object class and attribute of the SENC to the appropriate presentation of ECDIS display. Published by IHO as Appendix 2 of its Special publication 52 (S-52).

RESOLUTION : Capability of depicting detail, represented by the smallest distance apart at which two objects can be seen as separate. Depends on the pixel size, i.e. screen dimension divided by the number of pixels.

ROUTE PLANNING : An ECDIS function in which the area is displayed which is needed to study the intended route, to select the intended track, and to mark the track, its way points and navigational notes.

ROUTE MONITORING : The operational navigational ECDIS function in which the chart information is displayed, under control of the positioning sensor input, according to the vessel's present position (either in true motion or relative motion mode).

SAFETYNET : INMARSAT Broadcast Service for MSI - A service provided through INMARSAT'S EGC system which will be used by Administrations for the promulgation of Maritime Safety Information, such as NAVAREA and storm warnings, Notice to Mariners, shore-to-shore distress alerts and routine weather forecasts to the high seas and those coastal waters not served by NAVTEX. IHO proposes to include promulgation of electronic chart corrections as well.

SAILING DIRECTIONS : Information published in book form describing coasts, waters, channels, harbour facilities, etc., for use by mariners.

SOFTWARE : All programs which can be used on a computer system. In particular the system software (i.e. the operating system) consists of all programs which are necessary for the proper functioning of the computer and for the provision of appropriate services to the user. The application software consists of all programs developed for special user applications.

SOLAS : International Convention for the Safety of Life at Sea developed by IMO. The contracting governments undertake to promulgate all laws, decrees, order and regulations and to take all other steps which may be necessary to give the present Convention full and complete effect, so as to ensure that, from the point of view of safety of life, a ship is fit for the service for which it is intended (Article Ib of SOLAS)

STANDARD DISPLAY : The SENC information that should be shown when a chart is first displayed on the ECDIS and depending upon the needs of the mariner, the level of the information it provides for route planning or route monitoring may be modified by the mariner.

SYSTEM ELECTRONIC NAVIGATIONAL CHART : The data base, transformed by ECDIS from the ENC for optimum use, and updated by appropriate means. The SENC is the data base that is actually accessed for display generation and other navigational functions. The SENC contains the equivalent to the up-to-date paper chart.

UPDATE FILE : Special file in the ECDIS reserved for the storage of updates to ENC data.

WORLD WIDE NAVIGATIONAL WARNINGS SERVICE : A coordinated global service for the promulgation by radio of information on hazards to navigation which might endanger international shipping.

CHAPTER ONE

1. INTRODUCTION

The maritime industry has long been looking for a new technology to replace the traditional paper navigation chart and Notices to Mariners that will ensure that navigation becomes completely a science and less an art. One such new technology is the Electronic Navigation Chart (ENC) which, when properly presented on an Electronic Chart Display and Information System (ECDIS), could achieve the above goal and ensure safety at sea. Precise global positioning, accurate positioning relative to known dangers, integrated ship handling, remote control and single-handed bridge keeping are all technological imperatives which have driven the development of ECDIS.

With the remarkable progress of electronic technology in recent years, navigation aids have been modernized, and charts that are essential for safe navigation are also tending to change from the conventional paper chart to electronic chart which has the information content and the accuracy of the paper chart and is very convenient.

At present, for the security of maritime traffic, the International Hydrographic Organisation (IHO), in order to create and provide electronic data bases for charts, and the International Maritime Organisation (IMO), are cooperating in adopting international guidelines for electronic charts.

For the ENC to replace the paper chart, it is essential that the structure and content of the database be as standardised and complete as the current form of the paper chart or more so, as to be recognised as an internationally accepted document. The 'standards' must therefore deal with the display presentation,

updating, glossary and data base quality issues as well as exchange of digital data between hydrographic offices and the legal status of such exchange.

1.1 BACKGROUND TO ELECTRONIC CHARTS

The idea of the International Hydrographic Organisation (IHO) to address digital data formats began in 1977 when the Australian delegation suggested that the IHO's efforts to standardize charting symbology be expanded to include efforts to standardize digital data. Five years later, at the XIIth International Hydrographic Conference, the Canadian delegation recommended that an international format for digital data storage and exchange be developed. This initiative resulted in the adoption of an IHO resolution to form a committee to investigate the problems, storage medium, coding and transmission of digital data hydrographic data.

In 1983, the International Hydrographic Bureau (IHB) established a Committee on Exchange of Digital Data (CEDD). The committee was charged to:

- Explore the appropriate medium of exchange of digital data.
- Explore the feasibility and problems of such an exchange.

In January 1985, the IHB further directed the CEDD to consider the needs of the electronic chart in its discussions and of any future exchange format development. The IHO's North Sea Hydrographic Committee (NSHC), at its XVth Conference in 1984 recognising the rapid development of electronic chart systems, established a working group to study the matter. The group, in its report (Ref 2. 1986) recommended amongst others the need to give greater priority to the studies of Electronic Chart Display and Information Systems (ECDIS).

In January 1985, the IHB requested the International Maritime Organisation (IMO) to consider the questions of user requirements and legal aspects of ECDIS. In September 1986, the Maritime Safety Committee (MSC) approved the formation of an IMO study group, which is now known as the IMO/IHO Harmonization group on ECDIS.

At the XIVth Conference of the IHO, it was proposed to establish a Worldwide Electronic Navigational Chart Data Base (WEND). The proposal 28B which led to this decision was as follows :

" It is proposed to establish a special committee to examine the necessity of establishing a WEND and to examine the options, propose development plans and make detailed recommendations for the organization, under the auspices of the IHO, of a Worldwide Electronic Navigational Chart Data Base ".

At present, the IHO, in order to create and provide electronic data bases for charts, are cooperating with the IMO in adopting international guidelines for electronic charts. It is believed that the traditional chart will in the near future give way to electronic charts.

1.2 THE NAUTICAL CHART

Before we look into the heart of the information society - at the industries that produce information, the networks that move it, the corporations and institutions that use it and the scientists who study its technical and human facet- we need to step back and examine the long-range social, economic and technical trends responsible for the ascendancy of the information society. Only by understanding the long-term nature and direction of change can we chart a course for the future.

[Communications Canada, 1987].

The nautical chart is specifically produced for the use of the mariner or navigator in the interest of the safe passage of his vessel. It is therefore imperative that it reflects all the relevant data that could assist him to position his vessel relative to the shore and the sea bottom at all times. It must also indicate to him clearly and unequivocally, the known dangers to him and his vessel. The chart from the time of its compilation, through its production stage, storage, issue and use up to the point where it is either discarded or marked "not for navigation", must be corrected and maintained by the holder. This places an obligation on the Hydrographer or the hydrographic office to send corrections to the chart to the mariners and suppliers to enable them to update charts.

1.3 UPDATING THE PAPER CHART

National hydrographic authorities have as part of their obligations a routine system for updating all conventional charts on sale or supply to mariners. The NtMs are collated on a weekly or monthly basis and mailed through a series of agencies or directly to the mariner. The NtM contains such vital information as chart corrections, notices announcing the publication of new charts or cancellation of existing chart, corrections to list of lights, sailing directions, list of radio signals etc. The responsibility to insert the notice correctly lies with the mariner. The mariner adopts a standard format for symbology and records the presence of a change on both his chart and folio log.

To ease the plotting, the national hydrographic authorities provide a block correction showing the corrections to be applied. In the situation where the notice is large and complex, a chartlet, is printed by the hydrographic office to be fixed to the current edition of the chart or incorporated into a new edition of the chart. Such chartlets bear an individual Notice number, have their limits chosen carefully with respect to fitted points, and are chosen to be of the minimum size to encompass the

new material properly. The notice is framed in such a way that it provides a clear, concise and unambiguous instructions to the mariner to enable him correct his copy of the chart.

Local harbour authorities sometimes issue notices relating to the area to mariners in the vicinity. Such information does not constitute a permanent change to a particular chart until such time as it is promulgated by the national authority with responsibility for that chart.

Radio navigation warnings also provide early warning of navigation hazards to the mariner, which normally involve such issues as a sunken wreck, an unwieldy tow or the temporary extinguishing of a light. Sometimes such warning messages are broadcasted from coast radio stations until chart correction actions are taken. The mariner is expected to take note of coastal warnings and review them when he is approaching their geographical area of application. Coastal warnings being usually the most critical are broadcasted using voice communication at both MF and VHF. These warnings give short-term notice of general transient hazards, (such as lights temporarily extinguished) of interest only in the vicinity of the transmitter.

In order to ensure safety at sea, the IMO in conjunction with other world bodies developed the Global Maritime Distress and Safety Systems (GMDSS) to upgrade the existing worldwide distress and safety communications. The main purpose is to support the distress notification and search and rescue operations. The GMDSS provides urgent and safety communications as well as maritime safety information which include NtM, navigational and meterological warnings to the mariner.

1.4 LIMITATIONS OF THE PAPER CHART

The first geographical references to appear are in the Pentateuch and in the Book of Joshua (Joshua 3 : 1), and it is from the same eastern Mediterranean sphere that we find the earliest attempts by mariners to graphically record their experiences (Guy, 1989). The traditional paper chart has been used successfully by mariners for positioning their vessels relative to other vessels and known dangers. However, modern survey methods, the advent of electronic computer technologies and the emergence of the Global Positioning Systems (GPS) reveal certain limitations of the paper chart.

Without detracting from the successes of the paper chart, we can identify these limitations, and speculate as to why some of these are especially critical for successful use in marine transport today.

Depth information is represented by bathymetric soundings and contours on navigational charts. Soundings are represented as points while contours are represented as lines. The combination of these two data types is a graphical attempt of representing a three-dimensional surface of the seafloor. The medium on which the paper chart is presented being two-dimensional makes it difficult to represent accurately the true shape of the seafloor.

Modern survey equipment and methods collect more data than that depicted on the paper chart. The data content of the paper chart is limited by the scale of the chart. The data content of the paper chart is only a selection of the echo sounder trace. The United States Radio Navigation Plan (1988) states that except for resource exploration, the accuracy required for safe navigation of large ships entering harbours and harbour approaches is eight to twenty metres with a fix interval of six to ten seconds. If mariners could reap the full benefits of modern systems, then there is the need for a new approach to chart production and display.

With the application of differential corrections to GPS, the accuracy of position fixing has improved to five metres. This accuracy will meet the needs of most mariners. Kinal (1989) states that plans are under way to establish regional and even global GPS differential correction networks. For the mariner to reap the full benefit of this development, he must be able to relate the chart data to the immediate positioning needs. This is not practical if one attempts to plot fixes on a chart in the traditional way. Also to utilize radio navigation information that is presented at six to ten seconds intervals on a moving vessel, some form of an automatic display is required (Stephen, 1990).

1.5 STATUS OF HYDROGRAPHIC DATA

The advances of modern surveying technologies, the development of powerful low cost computer systems, progress towards increased standardization, improve digital information exchange and the development of powerful software to handle digital graphics data are rapidly changing the working environment of the hydrographer, the chartmaker and the mariner (Andreasen, 1995).

Positions of ships are currently fixed with the same electronic sensors that are fitted to survey ships. Modern survey ships have automatic sounding line track control and the position and depth of these soundings are automatically recorded. Also the development of multi-beam sounding techniques means that thousands of times more data than that by conventional echo sounding is collected. What is depicted on the paper fair chart is only a selection from all soundings. Information from other agencies concerning aids to navigation, dredge surveys, construction and status of harbour area are also required to maintain and update the nautical charts. Notices to Mariners compound the problem with the enormous amount of data transmitted on a weekly or monthly basis.

Hydrographic data has reached a point where a new technology is required to maximise its use and ensure improved safety at sea. Clearly, it is time for digital data handling, digital data communication, digital data exchange and the electronic chart.

1.6 THE NEED FOR ELECTRONIC CHART

The Electronic Chart (EC) is versatile, complex and potentially important aid to navigation decision-making. In a situation where a vessel is required to navigate through narrow and poorly-marked channels during conditions of poor visibility, precise positioning is essential and the electronic chart is obvious. The electronic chart could also provide valuable assistance to the mariner by warning him of deviations from the desired track much earlier and easier than by traditional systems. When failure to execute the planned route is detected, the EC can be programmed to generate various visual and audible alarms.

Lanziner (1990) states that the major concern of a pilot or master guiding a vessel through coastal or inshore waters is the speed, direction and position of the vessel relative to a navigational hazard. Any delays in processing incoming data into a form where this information can be extracted are of critical importance. For higher positional accuracy, the EC is the only choice since the computer may take some few seconds to process the incoming data as compared to the manual plotting of fixes on the chart.

Much of the power of the electronic chart comes from its ability to process data from a variety of sources and to detect and graphically show relationships between the data. This capability extends far beyond the use of a Kalman filter to integrate positional data from various navigational aids and to generate an error ellipse on the chart display as an indication of the fix quality (Lanziner, 1990). An electronic chart combines one's

position with supplied chart information. Hence it can be programmed to automatically warn of proximity to underwater and other hazards (Michelson, 1990).

1.7 ELECTRONIC CHARTS

The rapid technological advances in electronics and the advent of electronic computers have allowed scientists and engineers to design and build electronic systems which are capable of integrating data from the vessel's navigation systems and marine radar with the digital navigation chart. The object created by the integration of these components into a single system is what is generally referred to as an electronic chart (Ford, 1990). The IHO's Hydrographic Dictionary (1990) defines the electronic chart as :

" an integrated, interactive, navigation information system, with which the user can display the hydrographic and positional information that is required to conduct the safe navigation of his vessel. It comprises hydrographic and cartographic data bases containing information useful for navigation. "

Unlike the present paper chart which attempts to satisfy the information needs of mariners by being a display of a large area, the electronic charts will select and display information that is needed at a particular point in time and space. Much of the clutter may be removed from the screen and the mariner will see only the information that is currently relevant for his safe navigation.

Currently there are two types of electronic chart systems. One is known as Electronic Chart Display and Information Systems (ECDIS). ECDIS equipment and data will necessarily follow strict specifications laid down by IMO/IHO and subsequent to a planned future IMO resolution, will be accepted as an equivalent complying with the up-to-date charts required by Regulation v/20 of the 1974 Safety Of Life At Sea (SOLAS) convention. The ECDIS

system must display selected information from a data base known as System Electronic Navigation Chart (SENC) to assist the mariner in route planning, route monitoring and voyage recording and, if required, display additional navigation-related information. The planned IMO resolution will probably be approved at the IMO Assembly in November, 1995 in London.

The other type comprises all other electronic charts that do not comply with the ECDIS specifications. These systems are normally referred to as Electronic Chart Systems (ECS), but these are not accepted by the IMO as a paper chart equivalent. Hence, vessels fitted with non-ECDIS equipment will continue to be required to carry and use paper charts.

1.8 UPDATING THE ELECTRONIC CHART

The three methods by which the EC would be updated are manually, semi-automatic and automatic. The manual method involves the keying of the information via the keyboard by the Mariner or the Operator.

The semi-automatic method may be similar to the conventional method of updating the paper chart and has been divided into "telecom" and "non-telecom" based on the form of transmission. Using "non-telecom" method, the updating information would be recorded on diskettes, cassettes, CD's and distributed in a way similar to the paper Ntm's. This method will be used to service mariners in the vicinity of ports. Using the "telecom" transfer methods, the information would be transmitted to the mariner through the telecommunications networks.

With the automatic method, the chart will be updated without human intervention. The ENC and updates would be transmitted via satellite communications to the mariner. The data would be transmitted or broadcasted from the Regional Centres as shown in Figure 1. The Regional Centre will be discussed in chapter three.

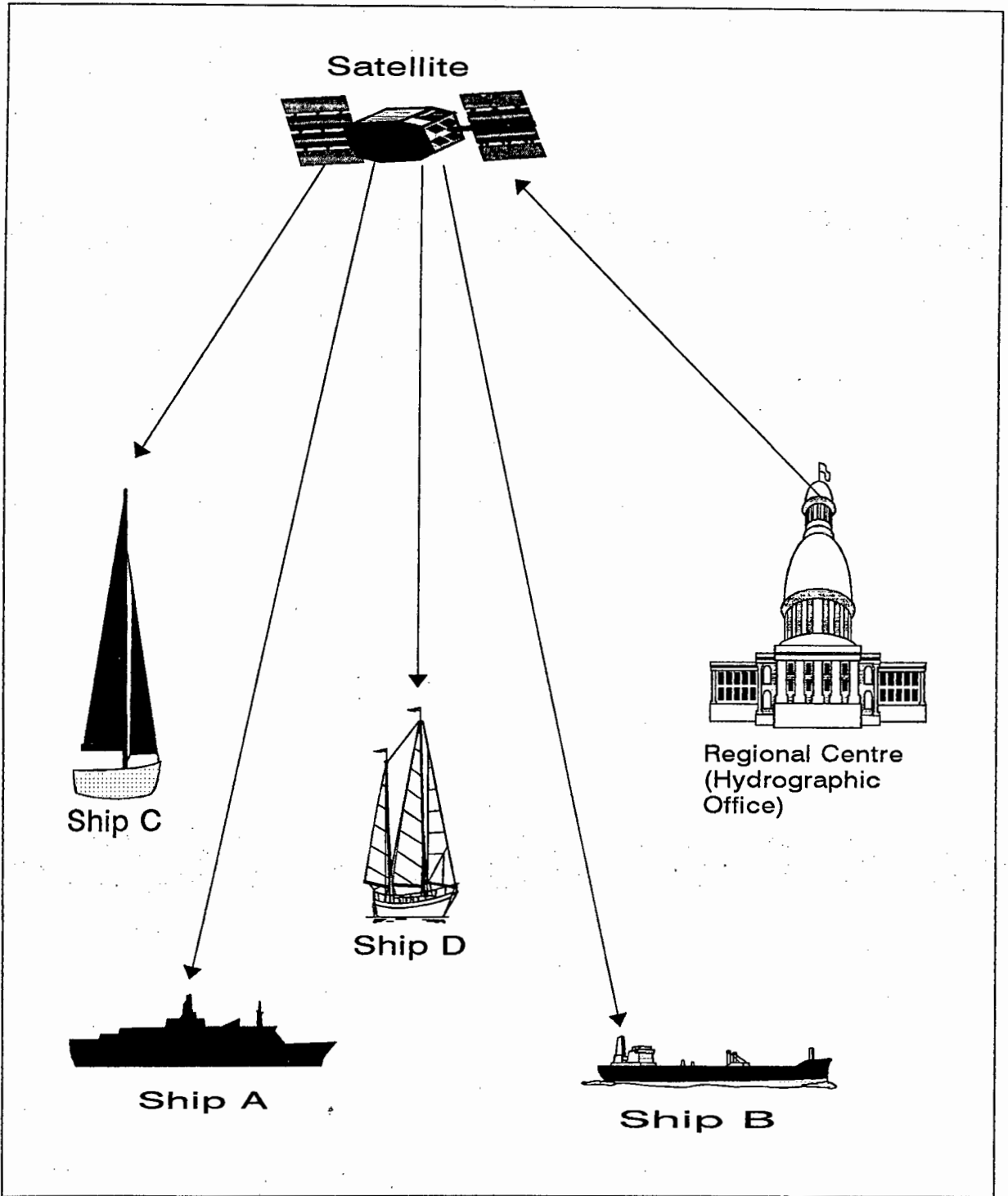


Figure 1

Electronic Chart data transmission based on satellite communications

Data prepared by the Member States would be sent to the Regional Centre to ensure that standard format is strictly adhered to. The centre would then distribute the data to all users through the INMARSAT EGC Satellite. All NtMs and shipping would be stored in data bases as soon as they are issued.

1.9 CHAPTER SUMMARY

The paper chart has been used successfully over the years. However, modern survey techniques and electronic technologies have revealed its limitations. The data content has always been limited by the scale of the chart. With the advancement in electronic technology and the emergence of differential GPS corrections, a new technology is required to effectively integrate the hydrographic data with other nautical information to ensure enhanced safety at sea.

The ENC is one new technology that the maritime industry has long been looking for to replace the traditional paper navigation chart and Notices to Mariners. For the ENC to replace the paper chart, it is essential that the structure and content of the data base be as standardised and complete as the current form of the paper chart or more so as to be recognised as an internationally accepted document. At present, the IHO, in order to create and provide electronic data bases for charts, are cooperating with the IMO in adopting international guidelines for standards of the electronic chart.

Unlike the traditional paper chart which attempts to satisfy all the information needs of mariners, the EC will select and display information that is needed at a particular point in time and place. ECDIS equipment and data will follow strict specifications laid down by IMO/IHO. Vessels fitted with non-ECDIS equipment will continue to be required to carry and use paper charts. The next chapter examines the requirements and functions of ECDIS

CHAPTER TWO

2. REQUIREMENTS OF ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEMS

2.1 INTRODUCTION

The development of ECDIS will allow for the availability of integrated navigational information to the navigator on the bridge and enhance safety at sea. However, having access to volumes of information will not solve the mariner's problem. What is necessary is the full awareness of the limitations and proper use of the data by the mariner. If one thinks of it as a system which will be updated without human intervention, then the mariner, hydrographer, software developer and the suppliers have a great deal of responsibility.

Currently ECs are used to aid safe navigation, harbour monitoring and vessel traffic surveillance. In the aviation industry it is being used to build vehicle and aircraft navigation systems. Oil exploration and production companies use the electronic charts for vessel management around offshore oil platforms. Electronic charts are also being used by port and harbour authorities to monitor traffic in several harbours around the world. The information is displayed on monitors, in a format that is as close as possible to what the mariner is familiar with in the paper format. This section of the report examines the requirements of ECDIS.

2.1 BASIC REQUIREMENTS

The basic requirement for ECDIS is to mirror the traditional paper chart and to incorporate other navigational information necessary for safe navigation. For the purposes of this report, the requirements have been categorized as follows:

- User requirements;
- Performance and operational requirement; and
- Data requirements.

2.2 USER REQUIREMENTS

Figure 2.1 shows the components of an ECDIS system and how the components interact to provide information needed by the navigator on the bridge.

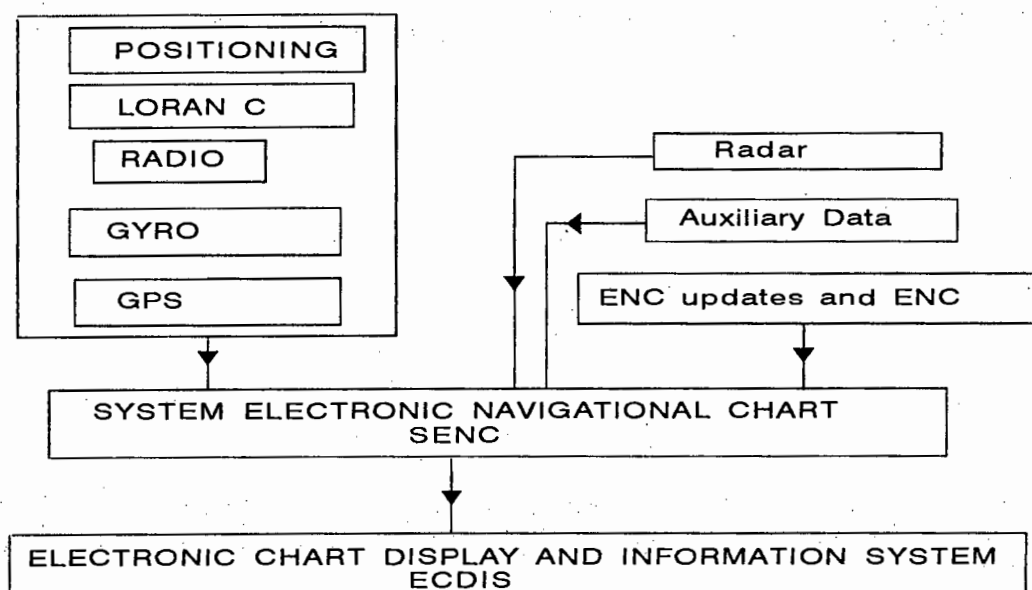


Figure 2.1 Components of ECDIS.

Source : Ford, 1990 but modified by the writer.

Currently, there are several ECDIS systems, with varying degrees of sophistication and price ranges. Since ECDIS has different applications, requirements, choice and type of information shown on the display depends on the application. The user requirements for ECDIS include:

- The ENC data and updates;
- An antenna for receiving radar information;
- Navigational system for positioning information; and a
- computer system for manipulating and displaying the SENC information.

The system should have the following minimum configuration:

- One CPU
- Data storage for SENC
- Data storage for updates
- One graphic display of size 270 by 270mm
- Colours: 64
- One text display
- Data input device
- Interface with clock, electronic equipment and electronic update media and other ships equipment when desired (Amendments to specifications for chart content and display aspects of ECDIS, 1995).

The ENC and ENC updates, positioning information from the navigation systems and radar information will be displayed by a high speed, high resolution, 27 inches by 27 inches colour monitor on the bridge. Radar information will be overlaid onto the chart data. Other information such as speedlog, anemometers and tides can also be incorporated. All the data are received by the SENC and displayed by ECDIS. The information can be provided and displayed at a variety of scales.

2.3 OPERATIONAL AND PERFORMANCE REQUIREMENTS

The operational and performance standards have been classified by the IMO under the following topics :

- display of information;
- provision and updating of chart information;
- scale;
- display of other navigational information;
- colours and symbols and colour discrimination on the display;
- display requirements;
- connection with other equipments;
- performance tests;
- alarms and indications;
- back-up arrangements; and
- power supply (IMO Performance Standard for ECDIS, 1994).

2.3.1 Display of Information

The information requirements for safe navigation include the ENC and ENC updates and other nautical information. A data base structured, formatted and issued by the hydrographic authority and other data by the mariner will be accessed by the ECDIS system. The system will transform the ENC into a form that is suitable for display by ECDIS. The data base obtained from the transformation of ENC by ECDIS is referred to as System Electronic Navigational Chart (SENC). This data base will consist of ENC, ENC updates and other nautical information. For a system to qualify as an ECDIS equipment, it should be capable of displaying all the SENC information.

The display information will be used for several purposes which include route planning, voyage recording and route monitoring. During route planning and monitoring, the system should be able to present the Standard Display (Information to be displayed when

the chart is first displayed by ECDIS) at any time by a single operator action. The reader is referred to Appendix 2A for the data content of the Standard Display. This information should be adequate for safe navigation. The mariner should be able to vary the content of this data depending upon the circumstances.

The information is required to be displayed at the largest scale available in the SENC for the displayed area. The system should be user friendly such that it will be easy to add or remove information from the ECDIS display. However, the system should not permit the removal of information contained in the display base (this information should be permanently retained on the ECDIS display). Again the reader is referred to Appendix 2B for the data content of the Display Base. In a situation where the mariner selects a safety contour from the depth contours, the system (ECDIS) should emphasize the safety contour over other contours on the display.

In displaying the ENC, ENC updates and all other information, the system is required to do so without compromising the integrity and accuracy of the data. To ensure maximum utilization of the hydrographic data, updates and other nautical information, the ECDIS should provide a method of ensuring that all data have been correctly loaded into the SENC. The last requirement of ECDIS with regard to display of information is its ability to clearly distinguish ENC data and updates from navigational elements and parameters. These elements and parameters are given in Appendix 2C.

2.3.2 Provision and Updating of Chart Information

Regulation V\20 of the 1974 Safety of Life At Sea (SOLAS) Convention requires all ships to carry up-to-date navigational information. It is important therefore, for ECDIS to ensure that the SENC information is up-to-date for the intended voyage. The information in the SENC will be updated on a regular basis.

The methods of updating will differ depending upon the nature of the information. By whatever means the updates are received (automatic or semi-automatic), the implementation procedure should not interfere with the display in use. Manually entered updates should be distinguished from the ENC information on the display and this should have no effect on the display legibility. For legal purposes the system should be capable of keeping records of updates and the time of application. Since updates via satellites will be implemented without human intervention, the mariner should be able to display updates separately to enable him to review the contents and to ascertain their inclusion in the SENC.

2.3.3 Scale

With ECDIS, the mariner will be able to display the chart data at different scales. Based on the shortcomings of the hydrographic data, it is expected that the mariner uses the chart at a scale specified in the SENC. The ECDIS should therefore provide an indication if the information is displayed at a larger scale than specified. This does not mean the mariner should or must not display the information beyond the specified scale. However he does so at his own risk.

The mariner will see the ship's symbol on display. This symbol indicates the position of the ship at any time. The system should give an indication if the ship's position is covered by an ENC at a larger scale than that provided by the display.

2.3.4 Display of Other Nautical Information

A more controversial use of ECDIS is the integration of radar and other nautical information. Radar information may be overlaid as Automatic Radar Plotting Aid (ARPA) tracks or as an overlay of the complete radar video 'picture'. The display of radar and

other nautical information should not degrade the SENC information and should be clearly distinguished from it. For the added radar and navigational information to fit the ENC on the display, the chart and the image should have a common reference system and should match in scale and orientation. The mariner should be able to adjust the display position of the ship to match the radar image with the SENC display. Whenever the mariner wants to remove the radar information, it should be done by a single operator action. The system should enable the mariner to carry out the above operations if it is to qualify as an ECDIS.

2.3.5 Colours and Symbols

The IHO specifications for colour and symbols are intended to contribute to the safe operation of ECDIS by ensuring that :

- the display is clear and unambiguous;
- there is no uncertainty over the meaning of colours and symbols on display; and
- mariners become familiar with ECDIS presentation without confusion (Provisional Colour and Symbol Specification for ECDIS, 1993).

The reader is referred to the IHO'S provisional presentation library for the full detailed description of the colours to be used on ECDIS display. It is expected that these colours be used to represent SENC information. SENC information displayed at the scale specified in the ENC is expected to use the specified size and/or colour for symbols, figures and letters. The ECDIS system should allow the mariner to select whether "own ship" symbol is displayed in the true scale or as a symbol.

2.3.6 Display Orientation

The IHO Special Publication 52 (SP-52) requires SENC information to be displayed in a "north-up" orientation. However, this will cause symbols and alphanumerics to be upside down for a south presentation. To avoid the confusion which may result from problems of interpreting the display (if "course-up" orientation were to become a regular requirement), the HO-data is required to be rotated with the north arrow. Thus all symbols, numbers, etc. should remain north-oriented. The IMO performance standard Display Base requires the north arrow to be always present on the display (Provisional Presentation Standards for ECDIS, 1991).

2.3.7 Colour Discrimination on the Display

ECDIS is expected to display diversity of information and to be flexible in presentation. The diversity of information as presented in the Special Publication 52 (SP-52) include :

- physical chart information, (e.g. coastline, depth contours);
- leading lines; traffic routing; specified areas; cautions; etc.;
- supplementary HO information from light list, etc;
- additional local chart information; user's notes; manufacturer's information;
- chart work such as planned route; electronic bearing lines and range rings; etc.;
- own ship's position and velocity vector; ships head and rate of turn; past track etc.;
- fix accuracy, or position check from secondary positioning system;
- ship handling options if appropriate, based on ship's characteristics;
- alphanumeric navigation information (ship's latitude, longitude, heading, course, etc.);

- information from radar and other sensors; and
- if appropriate, telemetred information from shore authorities.

The flexibility of presentation may include:

- displaying/removing various types of chart and non-chart information;
- selecting standard chart display or a thinned out display, and full or simplified symbols;
- using cursor interrogation for further detail;
- overlaying/removing radar video or radar target information (in order to confirm ship's positioning aid radar interpretation and to show the entire navigation situation on one screen);
- overlaying/removing various other sensor information, or information telemetred from shore;
- changing the scale or orientation of the display;
- selecting true motion or relative motion;
- changing screen layout with windowed display; alphanumeric information in the margins, etc.;
- possibility of "pull-down menus" and other operator interaction devices being alongside the operational navigation display and so interacting with it;
- given navigation and chart warnings such as " too close approach to safety contour" " about to enter prohibited area" "over scale display" " more detailed (larger scale) data available" etc.;
- possibly a diagrammatic representation of a computer evaluation of grounding danger; and
- possibly a diagrammatic representation of the immediate vicinity of the ship to aid in close quarters manoeuvring (Provisional Colour and Symbol Specifications for ECDIS, 1993).

The CRT screen of ECDIS is very much demanding. The diversity of information required to be displayed on ECDIS needs the maximum range of colours to be available. The mariner should be able to discriminate clearly the selected colours. Due to the differences in intensity of light on the bridge during the day and night, the system is required to be capable of displaying the SENC information in different colours.

The perception of colour differs from one person to another and the mariner should be able to display the chart data in any colour of his choice. This is required to enable the mariner to discriminate between the bright sunlight of the day, which washes out information on the display and the poor emission of light during the night. Figure 2.2 and 2.3 show the night and day time display of ECDIS.

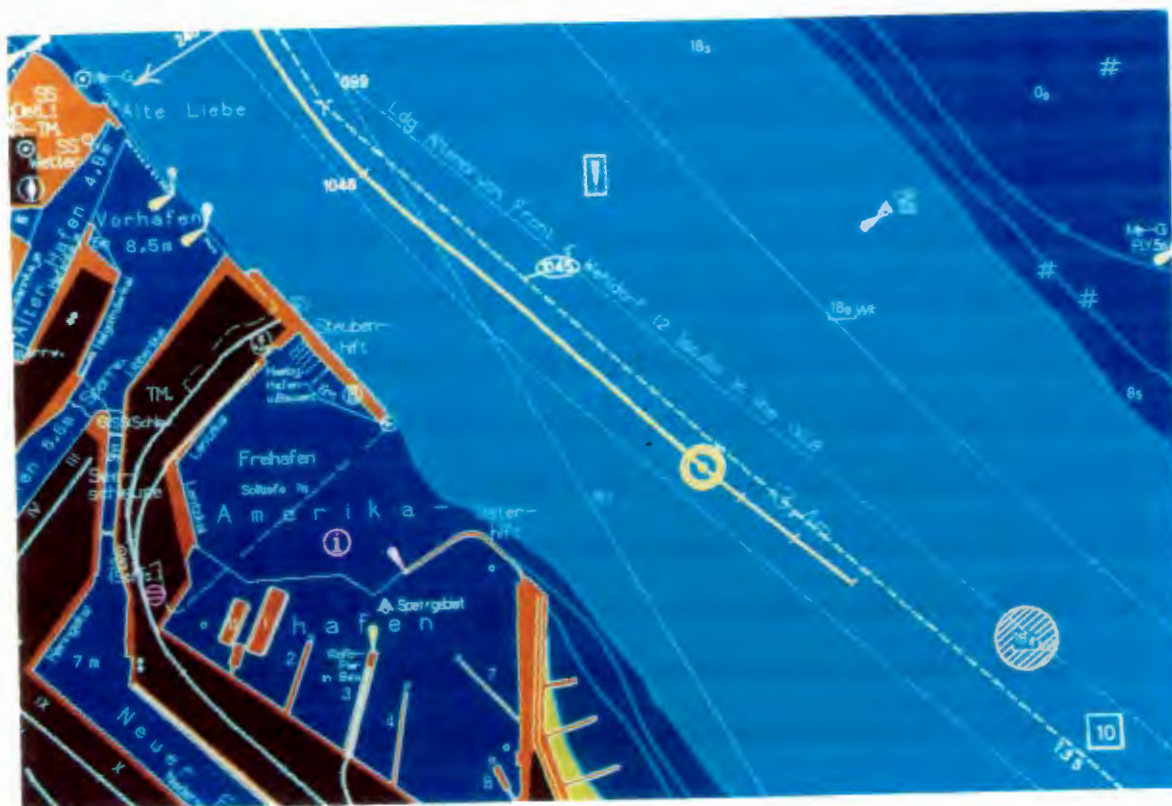


Fig. 2.2 Night-time display of ECDIS.

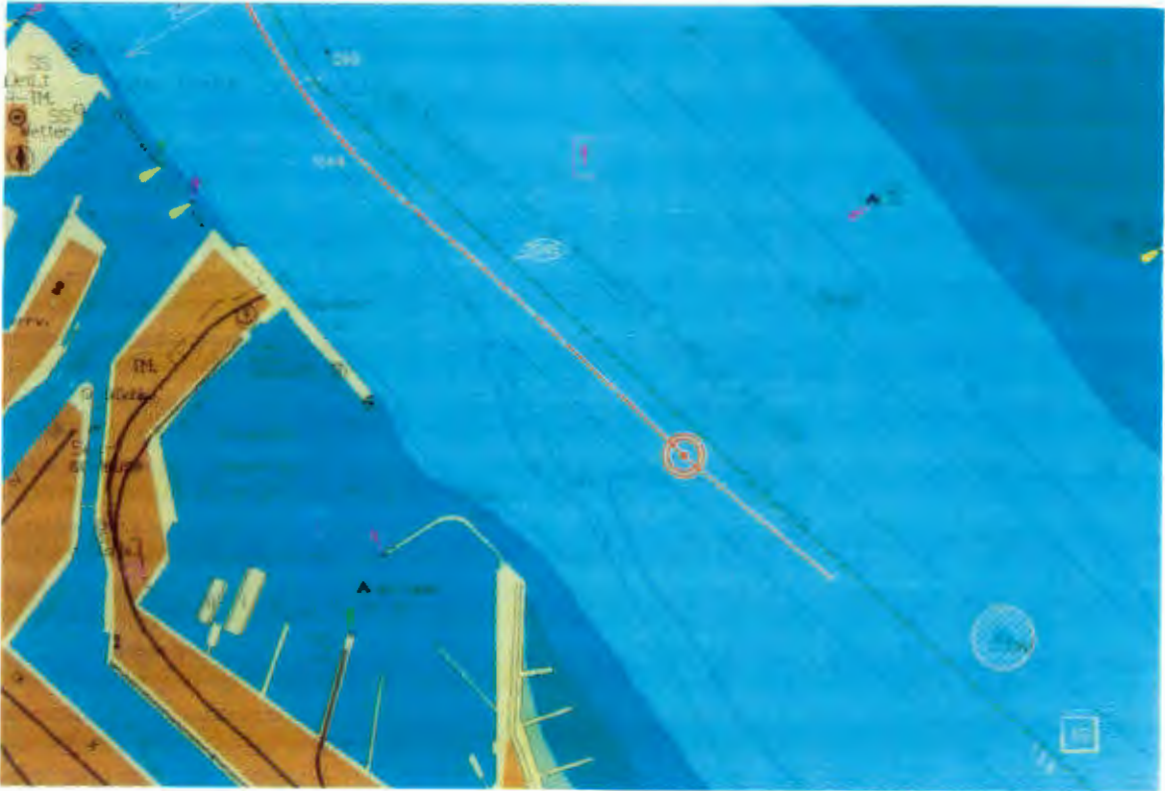


Fig. 2.3 Day-time display of ECDIS.

2.3.8 Display Requirements

The IMO Performance Standard (PS) requires ECDIS to be capable of displaying information necessary for route monitoring, planning and supplementary navigation tasks. These operations have different presentation requirements.

Route planning

In route planning, the system will be required to display a substantial amount of detail. The system will display more than the Standard Display of chart information with full details of symbols. This is due to the fact that route planning is normally

done under little or no stress. Waypoints and Route Libraries will be generated, modified and recalled. The route may be displayed at various chart scales to visually check on clearance from hazards or for example, if the mariner unintentionally plans a route across the boundary of a prohibited area or a geographical area for which special conditions exist.

To ensure safety of navigation, it should be possible to plan an alternative route in addition to the selected route. It is stipulated that the selected route be clearly distinguishable from the other routes. The system must indicate to the mariner if his planned route crosses an "own ship" Safety Contour or a boundary of a restricted area. The system should enable the mariner to specify the limits of deviation from the planned route beyond which an off-track alarm should be given.

Route monitoring

This is the time when the display will be used for immediate decision-making and the mariner will be under stress and the display will be viewed from a distance of several metres. The system is therefore required to present only the immediate relevant information in a clearly and unambiguous manner. Alphanumeric characters should be kept to a minimum to avoid clutter. The size of lines and symbols should be such that they can be easily interpreted at the operational viewing distance. The mariner will check whether a dangerous situation is developing from a distance and will only go close to the display if detailed information is needed. The important features are required therefore to be visible from several metres.

Due to the fact that the CRT screen is smaller than the paper chart, the IMO's PS requires ECDIS display to have the capacity for look-ahead. Thus ECDIS should display the sea area that does

not have the ship's position on display. When returning to the display covering the "own ship's" position, it should not take more than a single operator action.

An alarm is required to be given if, within a time or distance set by the mariner, "own ship" will cross the Safety Contour or boundary of prohibited area or a geographical area where special conditions exist or the ship will reach a critical point on the planned route. The full list of areas where special conditions exist is given in Appendix 2D. The alarm is also required when the specified limit of deviation from the planned route is exceeded.

The ECDIS will receive position information from continuous positioning systems such as GPS, Loran and Decca. The system is required to identify any discrepancies between these systems and should indicate when the input from the position system is lost. It is also required to indicate to the mariner any indication passed to it from position fixing systems. An alarm is required of the ECDIS system if the positioning system and the SENC are not on the same geodetic datum. During route monitoring, the mariner may want to display an alternative route in addition to the selected. The latter should be clearly distinguishable from the former and it should be possible for the mariner to modify the selected sailing route or change to an alternative route. It should also be possible for the mariner to query the data by coordinates input or by selecting features and displaying their attributes.

Voyage recording

Voyage recording is an important piece of information which can be critical in the aftermath of an accident. In navigation, the mariner keeps a record of chart updates and other information in his log book. This information constitutes the voyage record. The mariner is obliged by law to keep this information in case of an

accident. The IMO Performance Standard requires ECDIS to store and be able to reconstruct the navigation and verify the data base used during the previous 12 hours. The system must record time, position, heading, speed, ENC source and edition and, update history at one minute intervals. Due to the legal implication of the voyage record, it is stated that, it should not be possible to manipulate or change the recorded information.

2.3.9 Accuracy

During route planning, the system will be required to perform numerous calculations. Waypoints, distances and bearings between points will be calculated. The system is required to give results that are consistent with the SENC accuracy and afforded by the resolution of the display.

2.3.10 Connection with Other Equipment

The ECDIS will be connected to radar, gyro, GPS and other equipment for input. The system and the connected equipment are expected to coordinate to achieve a common goal. The system and the equipment must not therefore degrade the performance of each other.

2.3.11 Performance Test, Malfunction, Alarm and Indications

Due to the complexity of the system and the diversity of information to be displayed, the system is required to carry out on-board tests of major functions either automatically or manually. It should not only indicate to the mariner which module is at fault but also provide an alarm or indication of system malfunctioning.

2.3.12 Back-up Arrangements

The integration of radar with positioning systems using an electronic chart still involves a potential danger in that a system breakdown would deprive the pilot of two navigational systems (Jean-Pierre, 1994).

To avoid the situation where ECDIS failure develops into a critical situation, the SOLAS Convention requires ECDIS to have adequate back-up arrangement to ensure safety at all times. Mariners or ship owners are required to ensure that there are enough facilities to take over from ECDIS in case of its failure. The writer is of the opinion that mariners should carry the traditional paper charts for such emergencies.

2.3.13 Power Supply

The operation of the system and its associated equipment are powered by electricity in accordance with the 1974 SOLAS Convention. It should be possible to change from one source of power to another and interruption in power supply for a period of less than 45 seconds should not require the equipment to be manually re-initialized (IMO Performance Standard for ECDIS, 1994).

2.4 DATA REQUIREMENTS

The data requirements for ECDIS are very broad. A variety of data from different sources will be accessed and presented by ECDIS. Dale and McLaughlin (1988) state that quality land information should have most, if not all, of the characteristics below.

- **Accessibility** - The information should be easily and quickly obtained by the user.

- **Accuracy** - There should be little or no error in the data. Where errors exist, the user must be informed.
- **Appropriateness** - The information derived from the data should relate to the user's requirements.
- **Clarity** - There should be no ambiguity in the data or the information derived from it.
- **Comprehensiveness** - The data should be complete in spatial cover and content. All information that is relevant to the user should be included.
- **Currency** - The data must be up-to-date and accessible to the users at the right time.
- **Freedom from bias** - The information should not be altered or modified to influence the user.
- **Precision** - The data must measure up to the required standard.
- **Quantifiability** - Where appropriate, numerical information should be obtainable.
- **Verifiability** - Different users should be able to get the same answers to the same questions.

Due to the shortcomings of the hydrographic data, one cannot guarantee the quality of the data. This is because hydrographic data reflects the situation at the time of survey. The sea bed is not static and the sea surface topography changes every second. However, it is required that most, if not all, of the above characteristics be present in the ENC and its updates. The mariner needs access to data that is sufficient for safe navigation.

With the current electronic equipment available to the mariner, not all the data depicted on the present paper chart is relevant for navigation. The compass rose for example is no longer necessary to be shown on the chart for direction and orientation. With the EC, positioning information is obtained from electronic positioning systems such as the GPS. ENC distributors should ensure that only the relevant data goes into the ENC. To offer good services to the mariner, it is essential to ensure that the ENC data content is sufficient for safe navigation. The data should conform in format and content to that specified by the IMO/IHO. As indicated in Chapter One, the ENC can only replace the paper chart if the data content is enough for safe navigation. At minimum, the ENC should contain the Standard Display and the Other Information as shown in Appendices 2A and 2E.

2.4.1 Data Formats

Chart information may be stored in either Vector or Raster format. The type of format determines the quality and usefulness of the data. Raster data is stored as picture elements (pixels). Each pixel represents a minute component of the chart image with a defined colour and brightness. The elements are arranged in a matrix order, following standard computer display architecture. Raster images are obtained by video or digital scanning techniques, which 'photograph' either the existing paper chart originals or the lithographic plates.

Vector representation on the other hand is an attempt to represent the chart feature as accurately as possible. The coordinates space is assumed to be continuous, allowing all positions, lengths and dimensions to be defined precisely. The system links the spatial data to a data base of textual (attributes) information describing the chart elements.

Vector format systems offer the ability to split the chart information into layers. The mariner has some form of flexibility in displaying or removing the relevant and irrelevant information from the display. Unlike raster data, vector data requires considerable effort in collecting, collating, capturing, checking and correcting the data. The hydrographic office has a responsibility to ensure that the data is captured properly.

The ECDIS is a vector format system that makes use of the in-built intelligence in the data base. In fact, it is its ability to incorporate radar and other nautical information that makes it unique.

2.5 CHAPTER SUMMARY

A system can qualify as an ECDIS only if it can display all the SENC information. The display information is important for route monitoring, planning and voyage recording. The integrity and accuracy of the data should not be compromised when converting data from DX-90 to ECDIS format. The system should give an alarm if, within a time or distance set by the mariner, "own ship" will cross a boundary of prohibited area or geographical area where special conditions exist. The system should store and be able to reconstruct the navigation and verify the data base used during the previous 12 hours. For legal purposes, it should not be possible to manipulate or change the recorded information.

All the great things that ECDIS are expected to be doing will be useless if the data is not accessible to the mariner. At the XIVth International Hydrographic Conference (IHC) in 1992, it was proposed to establish a world centre for the Electronic Navigational Chart Data Base (WEND) which would be responsible for distributing ENC.

CHAPTER THREE

3. WORLDWIDE ELECTRONIC NAVIGATIONAL CHART DATA BASE

3.1 INTRODUCTION

At the XIVth Conference of the IHO IN 1992, it was proposed to establish a Worldwide Electronic Navigational Chart Data Base (WEND). This resulted from a proposal by the Norwegian Hydrographic Service to establish a foundation in order to develop the World Centre for Electronic Chart Data. Chile countered the proposal and suggested that a regional approach would be more acceptable in that it would allow greater participation by Member States.

A special committee was created to examine thoroughly the necessity of establishing a WEND suitable to the needs of international shipping and also examine the options for the administration, financial and legal and, as appropriate, technical organisation, under the auspices of the IHO. In February 1993, Australia presented a paper in Hamburg commenting on the establishment of a single state WEND.

It was stated that in hydrographic matters the expertise lies within the individual national authorities. Any attempt to centralise major functions will distance the individual from the real issues. The best place to ensure safety is at the national or regional level since each nation or region will be proud and protective of its waters. If the function of the WEND is distribution, then there is the need to address matters concerning ownership and liability. Australia's view was that although WEND is necessary, it does not fill a service vacuum.

In September 1993, the suggestion by Chile was accepted and the International Hydrographic Bureau (IHB) representative during the second meeting of the WEND special committee proposed a schematic plan to develop a WEND through linking regional centres. In January 1994, the name "Regional ENC coordinating centre" or "RECC" was proposed by the Committee of ECDIS (COE) updating working group following discussions held at its meeting in London. This name was found to be appropriate and was accepted by the special committee on WEND. The special committee concluded that there is the necessity for an international system of data base development for the production and distribution of ENC and urged the IHO to use its influence to satisfy the data needs for ECDIS (Adam, 1994). The committee developed a list of principles, a conceptual model of a regionally integrated data base service and a definition for WEND.

The writer believes that most issues that arise in ECDIS are more regional in character than global. For example, building a data base for important waterways at say, the junction of the Indian and Atlantic oceans, where the characteristics of the Agulhas, Mozambique and Benguela currents are of interest to adjacent sub-Saharan African states, it makes sense to maintain the data base regionally. Again, the waterways off Japan with their complexity and novelty in marine transportation, vessel design and traffic, together with language, needs recognition of a national or regional consideration.

Despite the progress being achieved, there still are technical difficulties with standards that are yet to be addressed. There are also technical difficulties with determining an adequate system structure for data base operations, as well as the necessary information management processes and distribution operations that must surround such a centre operating in a region or on a world-wide basis. Such technical difficulties suggest 'regionalisation' should be tackled in the first instance to ensure a more thorough testing of concepts.

This section of the report explains the conceptual model of the data base organisation of WEND making reference to the definition and the list of principles proposed by the special committee.

3.2 THE NECESSITY FOR WEND.

The necessity for WEND originated from the idea of the International Chart system. In 1969, Rear Admiral Langeraar in his paper "Towards an international chart" observed that some HOs compile charts of the same area at the same scale or close to the same scale. These charts, he said, contain the same data and serve the same purpose. The only difference was the language used in preparing the chart. He considered that many man-years have been wasted over the years in this act of effort duplication. It was also observed that charts kept by the UK, USA, France and the USSR were not identical. From these observations Langeraar proposed and the IHO subsequently endorsed that Member States could save funds if they jointly contributed to a unique international set of charts.

The international mariner prefers obtaining all data from one distributor. It becomes difficult when one has to obtain and utilize charts from each country visited. For this reason, ships on international voyages use charts produced by one of the three major world charting agencies. Not only does this simplify the chart collection process but also ensures that the mariner needs to process only one set of NtMs to plan and execute the entire voyage.

The list of principles developed by the special committee specifies amongst other things the need to avoid duplication of effort. It states that "the development of overlapping data sets from different sources should be avoided if possible". It also emphasizes legal liability to be recognised by Member States and urges them to have responsibility for preparation and provision of digital data and its subsequent updating of their own national waters. The full list of principles is shown in Appendix 3A.

3.3 DEFINITION OF WEND

The Special Committee defined WEND as:

"a common world-wide network of ENC data sets, based on IHO standards, designed specifically to meet the needs of international maritime traffic using ECDIS which conform to the IMO Performance Standards. The system will utilize HO national ENC data sets which are integrated and may be distributed and updated through regional centres. WEND represents an IHO system based on the cooperation of participating Member States."

The above definition indicate the need for a regionally integrated data base. It requires Member States to work together in developing data bases for international shipping.

3.4 ORGANISATION OF WEND

Adam (1994) states that " the advent of digital charts presents not only technical challenges to HOs and the IHO but an opportunity for a fresh start in designing a system of producing, distributing and updating this new product.

Figure 3.1 shows the conceptual model of WEND data base distribution. Individual HOs are not permitted to distribute digital updates to international shipping. However, they can distribute digital data to their national shipping in their own waters. They would be required to send their navigational information to their respective RECCs for packaging and distribution to international shipping. The RECC will either distribute the data to the mariner or send it to an agent for distribution as shown in the figure .

3.4.1 Financial Concerns

In order to ensure equity of finances, it is proposed that data should either be exchanged or transfer for some form of reimbursement. Thus individual HOs would receive payment for the data supplied to the RECC. The amount of reimbursement will depend upon the mutual arrangement between the HOs, the type of data provided and the volume of sales of the data by the RECC. Digital data formatted in accordance with the IHOs specification will attract more funds than non-digital data. The financial arrangement between HOs and the RECCS would be as shown by the "\$" sign in Figure 3.1.

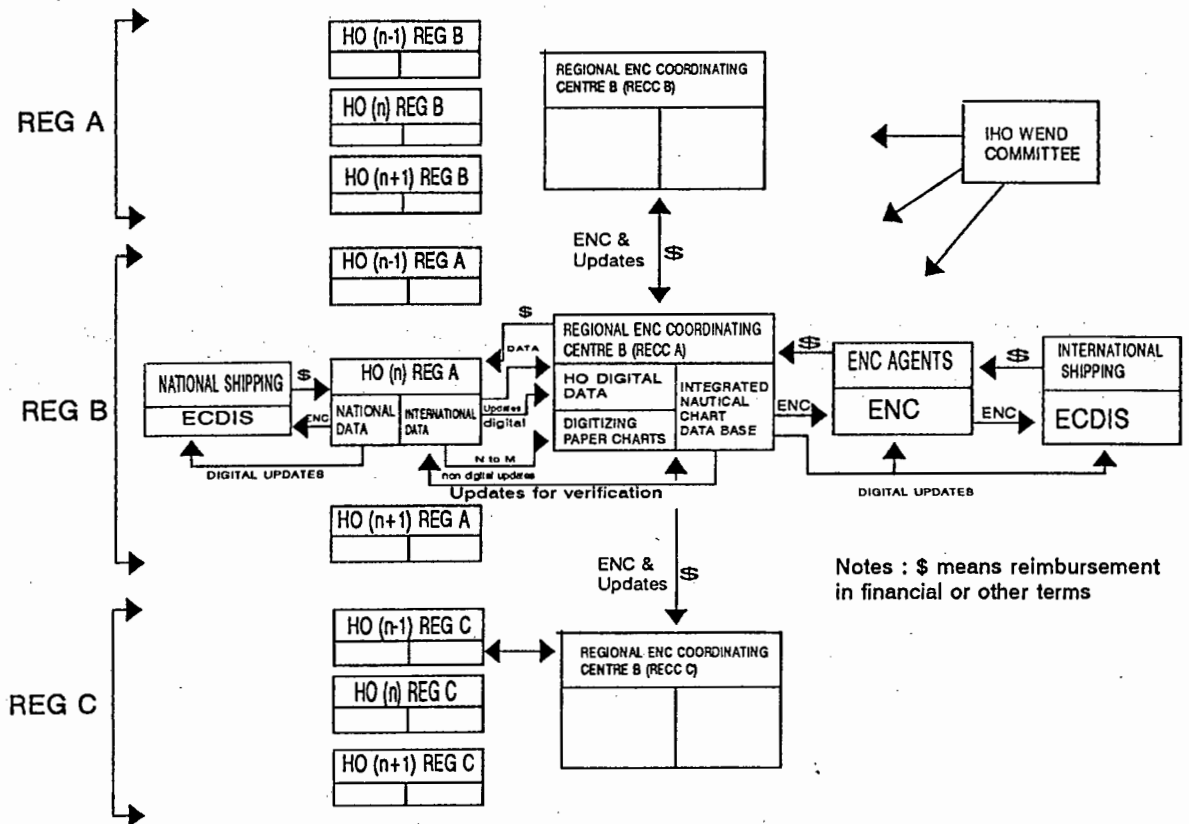


Fig. 3.1. A Conceptual Model of an organisation for a Worldwide Electronic Navigational Chart Data Base.

Source : International Hydrographic Review, vol. 71, 1994.

3.4.2 Data Quality and Legal Liability

Nobody wants to hear about legal liabilities in maritime accidents due to the cost involved. To avoid apportioning or shifting blame for maritime accidents (resulting from inaccurate data bases), the originating HO is said to be responsible for the quality of its own data unless it becomes modified in some way by the RECC. As shown in Figure 3.1, the RECC is required to confirm the validity of ENC and updates from the originating HO. Also, if the RECC digitises a chart on behalf of any HO, it must seek the consent of the HO regarding the accuracy and completeness of the digital form of its own paper chart.

Issues concerning adjustments required to be made by the RECC to integrate national data sets into regional data bases have not yet been fully addressed. However, it is believed that the RECC will bear some legal responsibility for the data if it makes such changes to the data.

3.4.3 Updating through RECC

Updating the ENC is one of the important elements in the WEND conceptual model. Figure 3.2 shows the arrangement for updating through RECC. Individual HOs will send their ENC and updates on disks, CDs, etc. or through the Internet to the RECC. The RECC will then distribute the data either through an agent or transmission media to the mariner.

If the latter, the RECC will transmit the data through satellite communication channels or HF broadcast to the ship. The ship's antenna then receives the information and automatically updates the SENC. The HOs and the RECCs will use any of the data transmission systems/media as would be agreed upon. The output of the ENC and updates from the RECC is required to be in Data Exchange 90 (DX-90) format. Financial implications of the updates

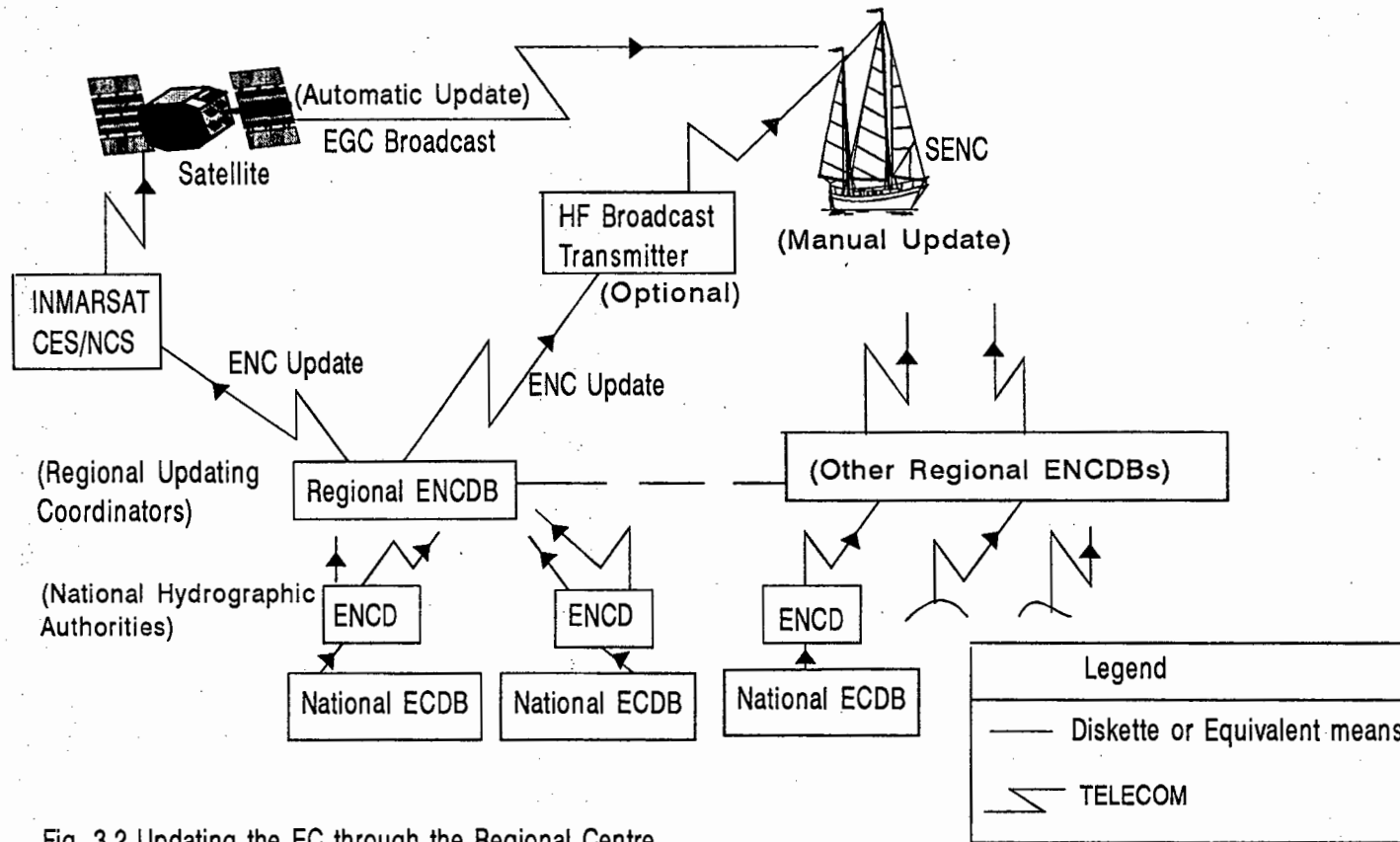


Fig. 3.2 Updating the EC through the Regional Centre.

After: COE Working Group on Updating the Electronic Chart (IHO, 1990).

have not yet been considered, but most of the HOs' view is that some form of reimbursement should be considered based on the labour involved in preparing the digital updates (Adam, 1994).

3.4.4 Sources of Data

There is no clear-cut agreement on the source of the digital data. Currently most HOs are digitizing their existing paper charts but it is recommended that HOs first digitize charts of the international series. Where the International Chart Series are not available, HOs are required to digitize national charts that most closely fit the International Chart scheme. HOs are encouraged to avoid developing overlapping data sets.

3.4.5 Training and Support

The WEND principles recognise the fact that some HOs may not be in a position to supply digital data. Others may not have the expertise in producing the data to the required standard. Principle 2a of the Special Committee on WEND encourages Member States to share ideas and the experiences gained. Some HOs may have to provide training and support for others.

3.4.6 Integration of RECCs

The purpose of establishing RECC revolves around supplying data to international shipping. For the international shipping to obtain all the data necessary for the intended voyage, there should be coordination between the various RECCs. As shown in Figure 3.1, RECCs will either buy or exchange data from other RECCs. For this process to take place, three methods have been suggested. The first option is to have a distributed system. In

this case individual RECCs will exchange data and updates by means of information transfer over a communications network. This model may be suitable for international shipping over a limited area.

The second option would be for each RECC to act as a purchasing agent for mariners and acquire data and updates from any other RECC. This model will require effective communication between all RECCs to ensure that the mariner receives all updates.

The third option is to have one central coordinating RECC which would hold the data and updates from all the other RECCs. This model is similar to the current practice where agencies provide worldwide coverage of the traditional paper chart. It will require effective communication and considerable logistic support and a technology that would be capable of processing, receiving and distributing a huge amount of data (Adam, 1994).

Each of these options has its own peculiar characteristics and limitations. Each option may be suitable for the establishment of RECC. The advent of fibre optics technology and the advances in the telecommunications industry will assist whichever option is chosen. Although the technology for the implementation is available one must not overlook the administrative procedure involved in ensuring that the mariner is provided with the latest and up-to-date information.

3.5 CHAPTER SUMMARY

The proposed conceptual model for RECC aims at serving the information needs of international shipping. It encourages diversification and minimal duplication of effort. It does not prevent any HO from developing its own folio for its navy or other national application. Member States are urged not to

compete in the provision of services for international shipping. It also urges Member States to share ideas and the experience gained.

The success of WEND will depend on the creation of quality data and this can be achieved through the experiences gained from the regions. Issues relating to updating are also crucial and are not developed at this stage. There is still much more work to be done in terms of technical feasibility and economic viability.

CHAPTER FOUR

4.0 NETWORKING AND DISTRIBUTED SYSTEMS

4.1 INTRODUCTION

Transferring data from one place to another depends on the data format, structure and the availability of transportation networks. Data stored on traditional paper charts are physically transported from one place to another. The ENC can be transported on tape or disk format. However, the communication networks may provide faster and more convenient means of transporting electronic data.

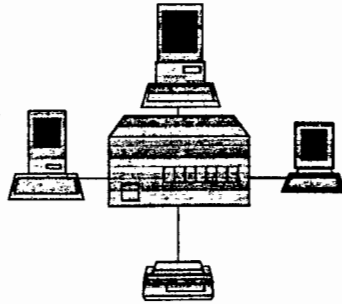
The advent of fibre optics technology and satellite communication systems have improved the ability of systems to transfer large volumes of data at a significantly increased speed. The advancement in the information technology associated with data transfer has made the world smaller. However, the improved technology has its own associated institutional and technological problems which need urgent attention. These issues will be discussed in Chapters Seven and Eight.

Many different combinations and configurations of computer hardware and software are available to exchange ENC and its updates between HOs. But problems may occur if the hardware and software are not compatible.

4.2 NETWORK CLASSIFICATION

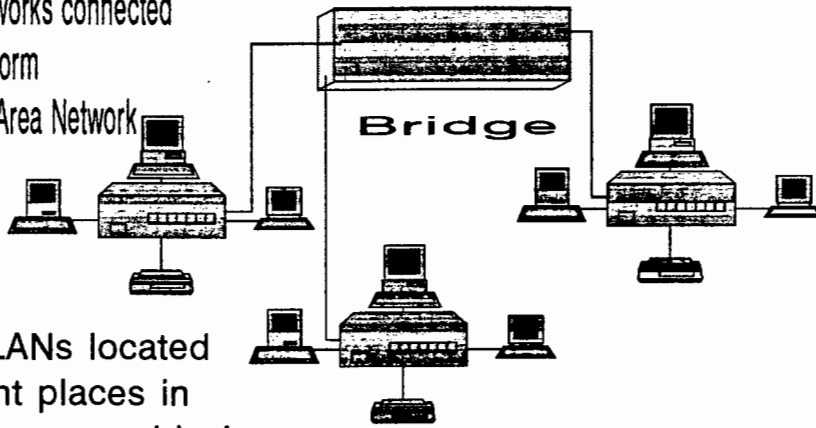
Networks are classified into Local Area Networks (LAN), Metropolitan Area Networks (MAN), and Wide Area Networks (WAN). Figure 4.1 shows these three classes of networks. According to Halsall (1994) LANs are used to interconnect computers

Multiple computers located at different places in the same building.



Local Area Network (LAN)

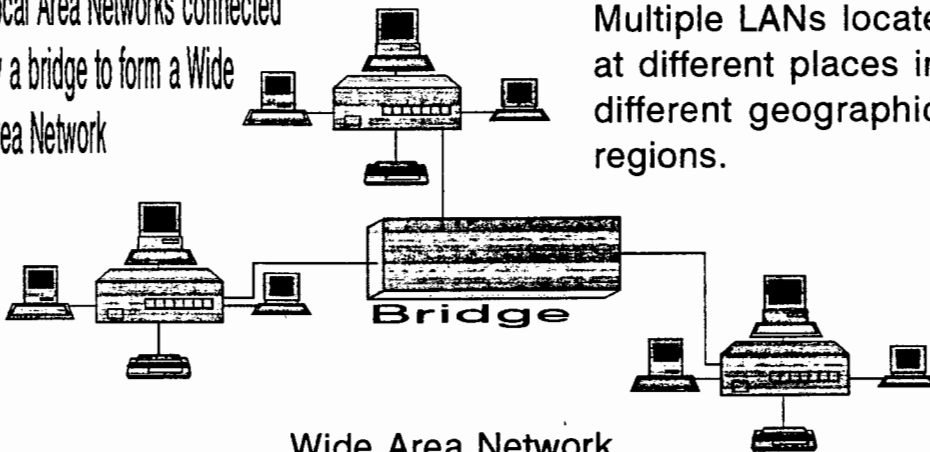
Local Area Networks connected by a bridge to form a Metropolitan Area Network



Multiple LANs located at different places in the same geographical region.

Metropolitan Area Network

Local Area Networks connected by a bridge to form a Wide Area Network



Multiple LANs located at different places in different geographical regions.

Wide Area Network

Fig. 4.1 Network classifications

(workstations, servers etc.) that are physically distributed around a single office or building or a group of buildings that belong to the same organisation. MANs are used to interconnect a set of LANs that are physically distributed around a town or city. WANs are used to enable computers that are physically distributed over a wide geographical area such as a country to communicate with one another.

In general a WAN is composed of two or more LANs connected by "bridges" or "gateways". Halsall (1994) describes a "bridge" as a device use to interconnect two or more LANs of the same type and "routers" if the LANs are of different types. Various network configurations have been designed for various purposes.

4.3 NETWORK CHOICE

The choice of network type depends on the needs of the user, the type of organisation and the physical area over which the network operates. Computers are networked locally by LANs, regionally by MANs and nationally/internationally by WANs. WANs are made up of two or more LANs linked by a bridge. While LANs are established to serve one organisation using compatible hardware and software systems, WANs may consist of multiply organisations using incompatible equipment. Supplying up-to-date ENC data to the mariner requires WANs since HOs are spread over very large geographical areas. The interconnected LANs may have, or use, different sets of protocols.

The speed at which data can be transmitted is a limiting factor for the use of LANs over long distances. Hence they are normally confined to small geographical areas. However, the introduction of fibre optics technology has increased speeds significantly.

4.4 NETWORK SPEEDS

The usefulness of a communication network depends on the speed at which data can be transmitted over the network. Network speed is important when transferring large volumes of data. The recent advancement in telecommunications have had significant impact on the speed of networks.

4.5 STANDARDS AND PROTOCOLS IN TELECOMMUNICATIONS

Currently, data transfer networks are based on the Open Systems Interconnection Environment (OSIE) with seven protocol layers. These layers are:

- 1 Physical layer;
- 2 Link layer;
- 3 Network layer;
- 4 Transport layer;
- 5 Session layer;
- 6 Presentation layer; and
- 7 Application layer.

Layers 1 to 3 depend on the network and are concerned with the protocols associated with the data communication network being used to link the two communicating computers. Layers 5 to 7 are application-oriented and are concerned with the protocols that allow two end user application processes to interact with each other through a range of services offered by the local operating system. The intermediate transport layer(4) masks the upper application- oriented layers from the detailed operation of the lower network-dependent layers (Halsall, 1994).

Various network protocols are engaged in making contact, conducting the session and terminating the session when computers are communicating. The processes involved in these phases of communication are different. "It is erroneous to think that

4.7 DISTRIBUTED SYSTEMS

Kramer (1994) states that distributed processing provides the most promising approach for the provision of computer processing. In a networked system, the interaction between the individual systems is essentially for file transfer. The systems communicate with each other but there is no cooperation.

Distributed systems are essentially an extension of networked systems. Similar to network systems, distributed systems consist of autonomous processors interconnected by a network. However, not only do the systems communicate but cooperate to achieve a common goal. Sloman (1987) defines a distributed system as being:

" composed of a number of autonomous processors and/or data stores supporting processes and/or data bases which interact in order to cooperate to achieve a common goal. These processes coordinate their activities and exchange information by means of information transferred over a communications network."

International shipping may require ENC from other RECCs. Data may have to be exchanged between RECCs. Distributed data base management systems (DDBMS) are capable of dispersing needed data out to users much more quickly than the traditional centralised data base management systems (Mase, 1989). Ceri and Pelagatti (1984) defined a distributed data base as:

" a collection of data which is distributed over different components of a computer network. Each site of the network has autonomous processing capability and can perform local applications. Each site also participates in the execution of at least one global application, which requires accessing data at several sites using a communication subsystem."

4.7.1 Distributed Data Systems

There are so many different formats and configurations by which data can be distributed or exchanged. Some of the most common ones are as shown in Figures 4.3 and 4.4. Figure 4.3A shows multiple workstations accessing the data base either through a LAN or remotely through a WAN.

Figure 4.3B shows a hierarchy of file systems. The data stored in the upper and lower levels are related. In fact the lower level stores a subset of the data in the upper level. Data from the lower level is passed on to the upper level at a predetermined time or date. Thus updates to the data are passed from the lower level to the higher level. Any changes made to the lower level will be effected at the upper level. However changes to the data stored at the upper level will not affect the data stored in the lower level. The upper level draws information from the lower level for decision making. This configuration can be applicable in the preparation of ENC. Hydrographic data and other nautical information can be stored at the lower levels and drawn to the upper level for the preparation of a chart.

Figure 4.3C shows a distributed file system consisting of machine capable of operating independently of the level at which the data exists. The systems at the lower levels are independent of the upper levels. The lower level systems are capable of processing, storing and in fact doing everything on their own. They can pass on and receive information from the upper level provided the system is compatible or mechanisms are in place to restructure the data. For the lower level machines to access each other, they must go through the upper level system. Such an application can be used for the RECC. HOs will send and, if required, receive data from the Centre. For one HO to access data from another, it must go through the Centre. The Centre will package the ENC from all the HOs and forward it to the mariner.

Figure 4.4A shows a split data system. In this configuration, the data format is the same for all regions but the content and location are different. Data from one Regional Centre to another is transported through the network since the format is the same. In this case, all the data transferred on the network would be formatted in accordance with the IHO's specification, i.e. DX-90 format. Each RECC will receive data in the correct format from other RECCs and does not need any interface for data conversion. This can be applicable when Centre A requires ENC data and updates from Centre B. A RECC wishing to acquire data from two or more other RECCs may do so through the network.

Figure 4.4B shows separate data in different locations forming an integrated system. Unlike the arrangement in Figure 4.4A, the data models or formats are different. This arrangement will be applicable at the national level where data from different sources are required to prepare or update the ENC data base.

In Figure 4.4C, we have identical copies of the same data sets in geographically different locations. This configuration is referred to as "replicated data". This configuration is used when there is the need to access large volumes of data sets and it is more economical or feasible to store redundant copies of the data than to transfer it between systems frequently. They are used for storing data sets that do not need frequent updates.

The fourth option is a heterogeneous data system configuration. This usually involves different organisations setting up independent computer systems for different applications. Normally the data sets within the various organisations are related to the same application but established for different purposes. Each organisation can access some, if not all of the data of another to effectively execute its mandate. But this may not be applicable in the WEND concept.

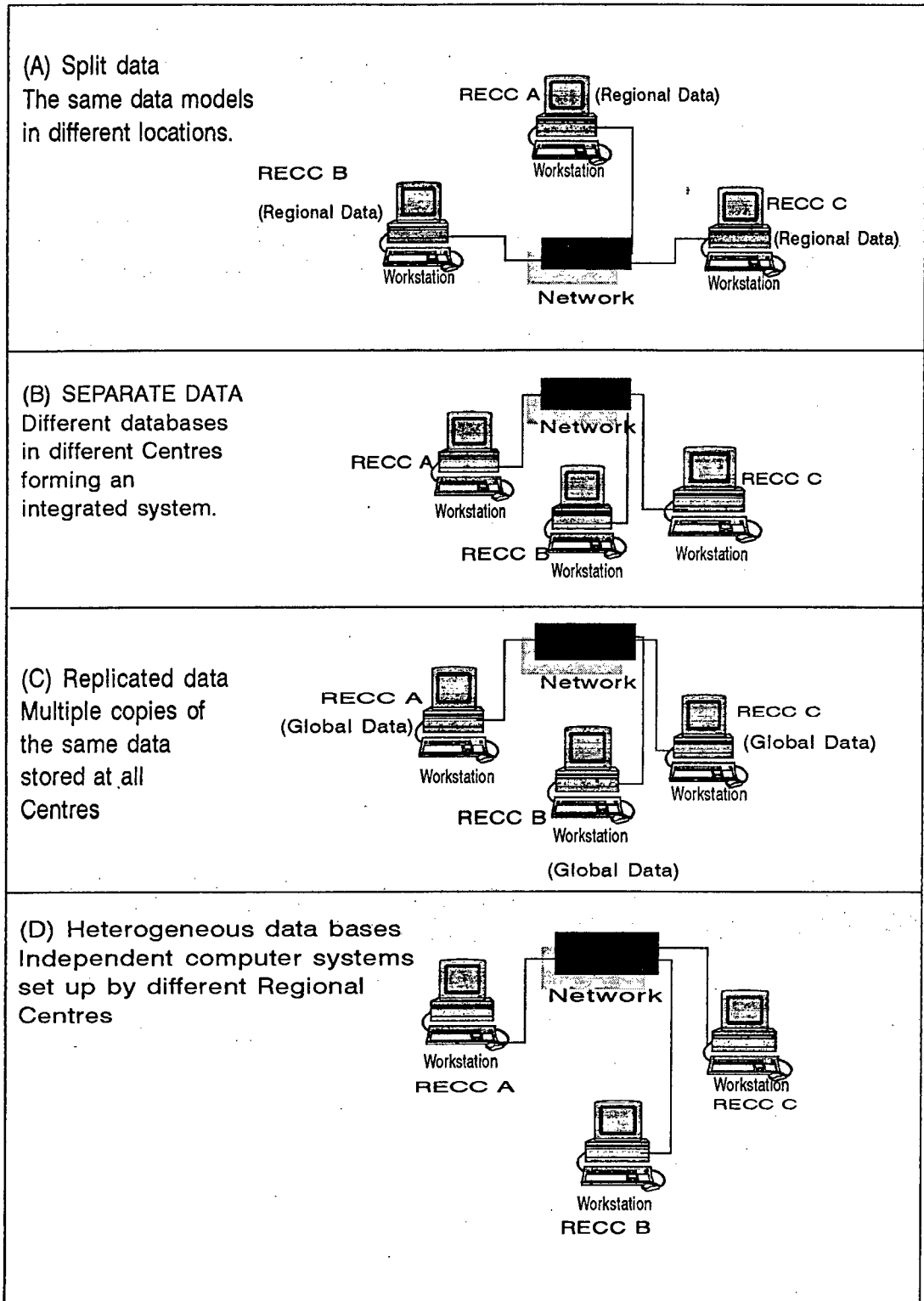


Fig. 4.4 Categories of distributed systems

[After : Ford, 1990.]

4.7.2 Benefits of Distributed Data base

Decentralisation of nautical information : Nautical information is held by various HOs which are decentralised internationally and have data bases located at several locations. To ensure effective operation, it may be better to have a data base administrator at each site and then construct a distributed data base to ensure the smooth exchange of data between HOs. Also it will be more economical to have a distributed data base system at various centres than to maintain a larger centralized computer centre (Ford, 1990).

Addition of personal workstations: Currently, workstations are widely used by most organisations. They are usually equipped with hard drives for maximum performance. These stations are used for electronic mail, job scheduling, mailing lists etc., and require a DDBMS to perform related tasks between offices.

High transaction rates : In the situation where large data transactions take place, it is more cost-effective to use DDBMS with a network of smaller machines than to purchase a large mainframe computer (Stonebraker, 1989).

Incremental growth: Distributed data base allows for a smooth incremental growth with a minimum degree of interference with the existing units when new branches are added. As the membership grows, the distributed data base approach will permit incremental growth without disturbing the existing units.

Reduction of communication overheads: Distributed data base system allows many applications to be local, therefore reducing communication costs relative to using centralized data bases.

4.9 CHAPTER SUMMARY

Transferring data from one place to another depends on the data formats, structure and the availability of transportation networks. Networks are classified into: LANs, when the interconnected computers are distributed around a single building; MANs, if the interconnected LANs are physically distributed around a city; and WANs, if the interconnected LANs are physically distributed over a wide geographical area.

The choice of network type depends on the needs, the types of organisation and the physical area over which it operates. Network speed, standards and protocols are important when transferring large volumes of data.

Distributed Systems are an extension of network systems which coordinates to achieve a common goal. Distributed data base management systems are said to be capable of dispersing needed data out to users much more quickly than the traditional centralised data base management systems. Distributed data base allows for a smooth incremental growth with a minimum degree of interference with the existing units when new branches are added.

As indicated in Chapter Three, WEND requires the establishment of RECCs. It is required that Member States in various geographical regions would come together and have a Regional Centre to coordinate the activities in the region to ensure improved safety at sea. To implement the WEND would require some form of infrastructure to be put in place at the Regional Centres. The following chapters examine the infrastructure requirement for RECC in sub-Saharan Africa. Chapter Five examines the issues to be considered in designing the infrastructure.

CHAPTER FIVE

5. DESIGN CONSIDERATIONS FOR A REGIONAL ELECTRONIC NAVIGATIONAL CHART COORDINATING CENTRE

5.1 INTRODUCTION

The key topics to consider in designing the infrastructure are user requirements, data, policy, finance, technology, organisational structure, data security, education, and research and development. The development of marine infrastructure involves two distinctly different sets of components. The first set is the physical or the technological components such as data bases, networks, distributed systems, data collection systems, and data manipulation systems. The other is the process components involving user needs definition, policy development, organisation of systems, financing and applications (Ford, 1990).

5.2 USER REQUIREMENTS

Different users will have different information requirements. The data requirements for national shipping may be different from that of international shipping. National or local shipping may require data in the national language.

For example, bathymetric information is important to all users of marine information. However, accuracy requirements differ from one user to another. While accurate bathymetric information may not be required by fisheries, it is in fact critical to other mariners. On the other hand, if the bathymetric data are collected to meet the requirements of fisheries then perhaps it cannot be used by the mariner for navigation purposes. Meeting

the shipping requirements also involves extra cost to the aquaculture operator wishing to use the data. However, if the data can serve a dual purpose and the collection process is not duplicated then the cost to all parties will be reduced. Hence there is the need to determine the users requirements when designing the infrastructure. Decisions should also be made on data collection methods, standards, scales, resolution, format, etc..

5.3 DATA PROBLEMS

Countries such as South Africa have taken the lead in developing data bases for ECDIS. While these countries are gaining more experience in ECDIS development, others have little or no experience in ECDIS. Member States of IHO with little or no experience may not be able to supply data to the required standards. There is the need for support and training from the experienced countries to ensure high data quality. Issues such as data quality, coverage, cost and data duplication need to be addressed.

Data duplication is one problem that requires urgent attention. Neighbouring countries may collect data covering the same area especially along their borders. The cost of collecting data is very much higher than its storage and hence duplication of data collection must be avoided and data sharing and exchange encouraged.

5.3.1 Data Access

The traditional paper charts and NtMs have to be mailed or transported to the supplier for distribution to the mariner. The speed with which the mariner receives the information depends on the transportation or postal system of that issuing country and that of the supplier. With the electronic chart, such a situation

will no longer be the case. The ENC and its updates will either be stored on disks and CDs and submitted to the navigator on entry to the port or transmitted through satellite links to the navigator. The accessibility of the data will depend upon the method of transmission adopted by Member States.

Currently with the development in the telecommunication industry, transportation and communication systems are available to move data in electronic format in a timely and efficient manner. Communication networks are available to share or exchange data among various users.

5.3.2 Data Quality

Some HOs are better equipped than others. While some are using modern survey methods, others are still battling with the old methods. Data collection methods, instrumentation used and data resolution may differ from one HO to another. There is the need for Member States to agree on the basic methods and procedures, instruments used and quality control measures.

The quality of data is the major concern of the navigator, ship owner and insurance companies. Insurance companies demand huge sums of money from ship owners if they are in doubt about the quality of data depicted on the nautical chart. The paper chart provided some form of security against unauthorised modification. With the Electronic Chart, another concern of users would be whether the data has been tampered with or changed since its transmission from one HO to another or not. Whatever system is implemented should ensure that the quality of the data is never compromised.

Some countries may have little or no up-to-date information available. Data in some HOs may not be suitable for ECDIS application. The status of data in each HO should be assessed to determine its suitability for inclusion in the Regional data

base. It is important for it to be assessed not only for content of the data but also to determine its age. This will enable Member States to decide which waters have to be resurveyed.

5.3.3 Cost of Data Collection

The major cost associated with creating electronic data is in the collection and processing of the data. The cost of data storage and transmission can not be compared to that of collection and processing. Some Member States may not have the economic might to cover the cost of data collection. There is the need for financial cooperation among Member States to enable the entire data in the region to be collected.

Most often agencies collecting information cover expenditure necessary to meet their minimum resolution requirements and are not willing to bear the added cost of increasing the resolution for the benefit of other possible users. However, if data is collected to a finer resolution than immediately required, it may not be necessary for other agencies to collect it again. In that case some form of generalisation could be applied to make it relevant to the needs of other users (Ford, 1990).

5.3.4 Cost of Data Conversion

Funding is required to convert the existing paper charts to electronic format in order to transmit it through the network. Until recent years, most of the data collected was stored in paper format in the form of charts or fair charts. To convert the data from analogue to digital requires a lot of funds. One must assess the need for the data before converting it from analogue to digital. It will not make economic sense if one converts all the traditional charts held by a state since some may be out of date.

5.4 FUNDING THE INFRASTRUCTURE

Funding is also required to build the infrastructure necessary to establish the RECC. The infrastructure will serve the interests of Member States, mariners, private companies etc.. Each Member State will be required to equip itself with some form of minimal digital or computing capability. However, the RECC would have to be well equipped to resource and execute the task expected of it. The question is should Member States contribute in financially supporting the centre ? This should be left for the IHO/IMO to decide.

The RECC will serve the interests of all Member States in the region and issues regarding funding the networks and distributed systems need to be addressed. Areas which can be exploited for funds include the governments of Member States, the private sector and possibly a combination of the two. To obtain funds from the government sectors, the paper work should be properly done. The politicians must be convinced that the network is as important as any other national project. Also the government must be convinced of the socio-economic benefits to be derived from building the networks.

The proper functioning of the RECC will improve economic activities in the region. The system can boost trade and tourism among the countries in the regions and other regions if the sea bed is properly surveyed and the mariner is confident of where to position his vessel. Insurance premiums for ship owners will be reduced as their risks and those of navigators are drastically reduced by ECDIS. The entire region and the world as a whole will benefit from the improved hydrographic service.

It should therefore be the responsibility of all governments to ensure that the necessary infrastructure is in place to provide the mariner with up-to-date information. Traditionally governments have accepted their commitment to provide information

to mariners as a social responsibility. As a result mariners pay much less for the nautical information than the actual cost of the data collection, processing and distribution (Ford, 1990).

To obtain funds from the private sector, investors would require a reasonable rate of return on their investment. Under such conditions one would be required to clearly define the demand for the service provided by networking the ENC and the markets. Oil companies, fishing industries and others may fund the networks if they could benefit from it. Thus if the data collected and transferred on the network could also be applicable to their industry and if governments of Member States recognised the need to provide up-to-date information to ships at sea, then perhaps funds would be committed to the project.

5.5 INSTITUTIONAL CONSIDERATIONS

This involves the non-technical processes such as policy development and other organisational behaviour patterns that influence the management and use of nautical information. Decisions that need to be taken include:

- which countries should be part of the group ?
- who controls the data bases ?
- who owns the data ?
- what pricing method should be adopted ?
- in what form should updates be made, on a cell-by-cell basis or in the form of electronic patch similar to the present paper chart practice with NtMs ?
- what technology exists to meet the needs and what technology still needs to be developed ?
- who sets the standards and what standards should be adopted ?
- at what frequency will the data be updated ?
- who will be liable for inaccurate information entering the user's data base ?

5.5.1 Ownership and Responsibility

Unlike other commodities, information does not deplete with use. Member States would want to own their data and dictate the terms as to who should have access to the data and who should not. Although the ENC data is meant for navigation, it could also be used for other purposes perhaps hostile. The question of ownership of data needs special attention. Member States must agree on their respective responsibilities regarding data quality, updates and frequency of updates.

5.6 TECHNOLOGICAL CONSIDERATIONS

The whole process of networking nautical information revolves around the technology available. Technology is associated with all aspects of the data exchange process from the data collection systems through to the display of the data by ECDIS. Currently most of the technology necessary for the marine activities is well-developed and operational in other fields like the telecommunications industry and the electronic data processing business. There is the need to consider what technologies are available and which will enable the RECC to function properly.

5.6.1 Enabling Technology

Currently, technologies for establishing the RECC and supplying data to the mariner are far-advanced. These include "Distributed Systems", satellites and land based communications networks. However, to put such a network in place requires a policy decision by Member States. Decisions to be made include :

- whether to use land or satellite communication systems or both for data transmission;
- if satellite the type of ground stations to transmit and receive the data;

- if land systems the location, functions and the role of the data distribution centre; and
- the type of network configuration that will be able to deliver the ENC updates to the mariner in near realtime.

The network can only be implemented after these decisions have been taken. Modern computer communication networks allow data to be transferred between multiple users with high reliability, transparent operation and multi-vendor connectivity (Allan, 1989). Most organisations are currently using communication networks in linking their various departments or divisions and to interconnect with other organisations. Various classes of network systems are available and the choice depends on the geographical distribution of the organisation.

5.7 COMPUTER SYSTEMS

The computer system is one of the most important things to consider when dealing with data processing, manipulation and transfer. The end-to-end time for transmission data between nodes in the network is a function of the computing power operating the data bases. The processing, packaging and transmission of ENC and its updates will involve a wide range of computers including mainframes, minicomputers, microcomputers etc.

For an effective design of a network which will respond to user request for information, one must not overlook the time the user is willing to wait for the information. Network speeds become less of a concern with LANs since many types are extremely fast. It is of much concern when dealing with WANs. For data sets containing graphics and large data sets, end-to-end response time could be slow with certain computer systems irrespective of the speed of the network (Ford, 1990).

In the networking and distributing environment, it is necessary to put in place certain security measures to protect resources from undesirable actions. A well-balance security programme must make use of both technical and non-technical solutions (Jackson, 1990) which will be discussed in the next section.

5.8 TECHNICAL NETWORK SECURITY

Before we discuss the topic, we need to understand the two important terms " objects" and " subjects" used in network security. The "object" refers to the information, applications, network components and other resources available to the user. The "subject" refers to the people who should have access to the objects. The technical security measures must address the following:

- What are the objects to which access must be controlled?
- What are the subjects whose access must be controlled?
- What are the threats which access control must prevent?
- What are the mechanisms to enforce access controls?
(Janson and Molva, 1991)

The first two questions simply mean 'what to protect from whom' while the last two mean 'what to protect against and how to do it'. The threats and attacks from which the network must be protected include:

- Disclosure;
- Modification;
- Denial of use, misuse and abuse; and
- Repudiation.

Disclosure - is the unauthorised release of information to intruders carrying out passive attacks such as a wire-tapping. Such attacks can be prevented by cryptographic means.

Modification - is the unauthorized alteration or modification of information by intruders. An intruder can cut the network link, insert a computer at the link and modify the information as it passes through. To prevent such attacks, the network links must be physically protected over its entire length.

Denial of use, misuse and abuse - is the denial of network use to legitimate users. Several attacks can result from this. While some legitimate users will be abusing the resources of the network, others may physically disable switch nodes.

Repudiation - denial of network usage by a legitimate user, by refusing to admit that he sent or received some information or that he used some resources (Janson, 1994).

5.9 NON-TECHNICAL NETWORK SECURITY MEASURES

These security measure are meant to discourage or deter unauthorized users. There are various forms of security measures that could be adopted. Each measure has its own peculiar characteristics and may not be sufficient to prevent the infiltration of the system. A combination of these may provide the protection necessary to keep away intruders. These security measures include (Schweitzer, 1990; and Dale and McLaughlin, 1988) :

- **Physical security** - this is the means by which unauthorised parties are physically prevented from coming into contact with the computing environment or computer resources. This protection can take the form of guards, receptionists, door access control such as keys, combination locks, magnetic cards, restricted access, fencing etc..

In a distributed computing environment, physical security may be difficult to maintain and may not offer the solution. This is because access to the system is more likely to come through illegal entry to the network from remote terminal than illegal physical entry.

■ **Administrative and procedural control** - these controls are aimed to lessen the likelihood of an 'insider' performing unauthorized activities. According to Jackson (1990) 70 to 80 percent of all security threats come from insiders. These controls may be implemented by :

- authorization schemes in which the access and uses of the resources are specified for individual users;
- regular activities designed to provide quality assurance functions over the resources;
- use of independent or neutral parties to provide objective checks and balances on activities;
- auditing of activity; and
- use of intellectual property ownership agreements and other contractual arrangements to control the environment (Anderson, 1992).

■ **Legal framework** - this consists of the laws and the regulations that should be adopted to deal with the broad social issues in the environment in which the system is situated. To discourage or deal with the breaches of computer security, laws relating to security and privacy should be adopted. If the laws and technical measures do not serve as an effective deterrent, then the law should be seen as the final recourse to punish intruders after the act.

5.10 CHAPTER SUMMARY

The key factors to consider in designing the infrastructure for the RECC are data, finance, technology, security and policy. Data problems to be considered include quality, accessibility and duplication. Financial issues include the cost of data collection, conversion, training, education etc..

Institutional issues such as ownership and responsibility, frequency of update and legal liability must be clearly defined. Technological decisions to be made include the type of data transmission systems and network configuration to be used. The threats and attacks from which the infrastructure must be protected should be identified. It is only after these issues have been addressed that the infrastructure can be built.

CHAPTER SIX

6. INFRASTRUCTURE REQUIREMENTS FOR A REGIONAL ELECTRONIC NAVIGATIONAL CHART COORDINATING CENTRE

6.1 INTRODUCTION

The proposed infrastructure is designed to support the information needs of international shipping. The infrastructure must be built with the technological and institutional issues in mind. The components of the proposed infrastructure must also address the technological and institutional issues discussed above.

6.2 INFRASTRUCTURE COMPONENTS

The infrastructure for the RECC should consist of data collection systems, data bases and transmission systems necessary to provide an effective information service to HOs, mariners, other RECCs, and users of the ENC. According to Baker (1989) the infrastructure requirement for a marine information network must consist of information providers, data base producers, system operators, communication systems and networks standards, and hardware and software products. The three principal characteristics common to all infrastructures identified by Anderson (1989) are:

- an integrated network;
- a common set of standards; and
- a design that facilitates simple third-party access.

Baker (1989) also suggests that "the infrastructure should consist of data bases, networks and user systems".

6.2.1 Data Collection Systems

As indicated in Chapter Five, some HOs have little or no up-to-date information and may require a re-survey of its waters. These countries may not have the necessary equipment or expertise to collect the data and may depend on the RECC for data collection.

Over the past centuries, hydrographic data has been collected by different HOs using different techniques and instruments. As a result some of the data collected may not be suitable for ECDIS application for various reasons which include accuracy, incompatibility etc. Also other users requiring the same data may not be able to use the data for similar reasons .

Whenever the pavement of a road network is upgraded, it attracts more drivers and the volume of traffic increases. Similarly the digital hydrographic data will attract more users in the near future. In order to exchange or share information, it must be acceptable to all parties in terms of scale, accuracy, resolution, format compatibility etc. One must therefore consider the information requirements of all possible future users when planning data collection missions.

From the technological point of view there are several options available such as :

- remote sensing tools, conventional devices and automated systems.

From the institutional point of view some of the questions to be answered are :

- what technology will be used ?
- who will collect or capture the data ?
- who pays for the data conversion ?
- when will the data be collected and updated ?
- who maintains the data base ?

6.2.2 Data Bases

Currently very few data bases exist. These data bases were built for specific users and for specific purposes. They were not built with data sharing or exchange in mind and as a result they may not be compatible or useful for ECDIS application. Technological issues will include developing interfaces to efficiently and accurately transfer the data from one system to another thereby making it useful for ECDIS and other applications. Other technological issues include data base management systems and storage devices and data models. Institutional issues to be resolved include what data structure to use, where the data bases will reside and who provides funding for maintenance.

6.2.3 Data Transmission Systems

There are various forms of data transmission system available to the marine community. These include the air, sea, post, and road transport systems. Data may be transported physically in hard copy, tapes, or magnetic disks. It can also be transmitted through the INMARSAT EGC satellite system or via land-based telecommunication network systems.

Some of the institutional problems to be addressed include: data quality, legal liability, funding, maintenance, network speed and architecture, and the physical area of coverage. Technological issues to be addressed include software and hardware for data transmission, data and network security, telecommunications and satellite communications technologies.

6.3 SYSTEM OPERATION AND MAINTENANCE

The system must be capable of fulfilling the functions for which it was created. There is the need for personnel to service the equipment, install upgrades, plan improvements to the system etc.

Institutional issues to be dealt with are the qualifications of personnel, education and training, number of staff required to operate and maintain the system and funding. Technological problems include the appropriate technology to provide the acceptable level of performance.

6.4 DISTRIBUTION AND PRESENTATION

As the data is transmitted through the network, it must not compromise its integrity. The design of the system must also take into consideration the presentation of the data to the user.

6.5 STANDARDS

One major problem with data sharing is the lack of standards. To date very little has been done to standardize data bases, data collection systems and methods, data display devices and data analysis methods. Considerable amount of success has been achieved in the area of telecommunications. Digital transfer models like the Integrated Services Digital Networks (ISDNs) and Public Switched Data Networks (PSDNs) have been accepted as standard throughout the telecommunication industry. Some authors believe that even with the ISDN and PSDN, full standardization may never be achieved since new products continue to hit the market. Stonebraker (1989) commented on SQL and UNIX, "versions offered by various vendors also differ in minor ways".

Although standards need to be adopted in networking ENC, it should not prevent future improvement of the system. The best standard is the one that will allow improved versions of the system to be introduced and perform the same functions as before and add new features (Ford, 1990). MacDonald (1989) expressed his concern about standards by saying "waiting for the ultimate

standards to be developed and implemented can lead to long periods of inactivity and delays in establishing a marine information network".

6.6 CHAPTER SUMMARY

The proposed infrastructure is designed to supply up-to-date information to international shipping. The components of the infrastructure should address the technological and institutional issues discussed above. The required infrastructure should consist of data collection and conversion systems, data bases , data transmission systems and manpower.

CHAPTER SEVEN

7. IMPLEMENTATION STRATEGIES

7.1 INTRODUCTION

The methods or strategies for implementing RECC will differ from one region to another. The implementation strategy will depend on the information available and existing framework of the region together with established policies for information as well as available personnel, technology and financial resources. This chapter identifies some of the issues with the aim of providing some general guidelines for implementation RECC in sub-Saharan Africa. The report identifies the need to create the awareness of change, achieve user and political cooperation, dealing with organisational conservativeness, developing the networks and putting in place security measures as the key issues to the success of the implementation process. The success of RECC in the region will depend on the cooperation of Member States and their willingness to share ideas and experiences.

One important strategy for implementing a system is to assess the existing framework and design the proposed system around it. The proposed system must be designed around the users' needs as opposed to tailoring the users' needs to the system. Some research is necessary and must precede formulation of policies and recommendations (Nanton, 1993).

7.2 CREATING THE AWARENESS OF CHANGE

The first phase of the implementation process involves creating the awareness of the need for the RECC and identifying Member States who will be willing to contribute data, the user group and their needs. This may be accomplished through seminars, interviews, conferences, questionnaires, and workshops. This will not necessarily provide information for designing the system but will give some indications of issues to be addressed by the system. As stated previously the ENC may attract more users and will not be used for only navigational purposes. This consultation will also reveal what information exists and in what format and how it has been managed. There is the need to create the awareness that the current methods of storing, retrieving, updating charts etc. are inadequate and deserve a new approach if the potential of modern technology is to be fully exploited. One must clearly indicate the problems associated with duplication of data collection, data sharing, inadequacy of analysis and output capabilities and its economic implications to Member States.

Technological awareness must be created by organising an exhibitions. The capabilities of ECDIS in navigating through narrow channels and under conditions of poor visibility can be demonstrated. The idea is to create the awareness of the improved safety at sea which has resulted from the ECDIS technology in other places of the world. Nanton (1993) states that in addition to the assessment of user needs, one must investigate what previous attempts have been made to establish similar information systems, how these were executed and what measure of success was achieved. A detailed report of the need assessment is essential.

7.3 ACHIEVING USER AND POLITICAL COOPERATION

One of the critical success factors in the implementation process is to gain support from users and at political levels. The proposed Centre can be implemented in two ways. These two processes have been described by many authors as "Top-down" and "Bottom-up" approaches. Both approaches have their strengths and weaknesses. The "Top-down" approach involves the use of politicians to implement the Centre. It has the advantage of ensuring cooperation among users even if they do not agree to the concept of information exchange. As a result the implementation stage of the system can be more quickly reached. However, the politicians must be convinced of the socio-economic and political benefits to be derived from the system. The danger in using this approach is that people are forced to do things against their will.

In the "Bottom-up" approach, the system is sold to the users and then, based on their support, respective politicians are pressurized to support the project. Normally this approach takes longer than the "Top-down" since winning political support presupposes user agreement in principle. The advantage of "Bottom-up" approach is that users place more confidence in the system designed in that manner (Nanton, 1993). To gain political support for the system, the paper work should be properly done.

7.4 DEALING WITH ORGANISATIONAL CONSERVATIVENESS

In Africa some people view computers as a threat to their job security. The problem is that some people would love to do the same type of work each day. Others feel that computerisation is a very complex concept which requires special people. In fact most people involved in the production of the traditional paper chart may feel threatened by this concept of computerising their job. The fear is that they may lose their jobs since they are not computer literate and cannot deliver.

Similarly, some local mariners who are conversant with the paper chart may be threatened by ECDIS. According to Duncan (1991) the traditional role of developing countries has been one of data collection rather than information processing. Information needs have always been satisfied by contracts awarded to foreign consultants who sometimes collect the data themselves. He said these countries have not had a history of using locally generated information and may tend to place more trust in foreign expertise and information processed abroad than in a locally established system. The effect of this locally is that there are insufficient suitably trained personnel. Where there is the expertise, those in possession of the information tend to view this capability as bestowing on them some degree of power. Any attempt at broadening the information base will be seen as a threat to their power and may do everything within their means to resist the change. The architects of RECC should clarify the issues of the change process to alleviate people of this fear.

7.5 NETWORK DEVELOPMENT AND IMPLEMENTATION

The organisational model for RECC proposed by the special committee on WEND requires an information network to be put in place. The implementation of RECC could be achieved in two phases. The first phase involves the creation of Directory of Marine Information (DMI) and connecting to countries in the Region. The regional centre should have a data base manager who will be charged with the responsibility to maintain and update the DMI. To obtain navigation information about a geographical area, the DMI should be accessed. The DMI should contain the following :

- List of countries contributing to the RECC;
- Geographical area of the data coverage;
- Scale of charts;
- International chart series number;
- Currency or age of information;

- Policy on data exchange;
- Category of navigation information; and
- Updates to charts.

When a user accesses the DMI by geographical area, the system should provide information about the various chart scales available, the chart number, policy on data exchange etc. The second phase would be to connect to other RECCs. In this case the RECC maintains its data bases and holds complete control but makes it available to other RECCs on demand. The network must be aimed at:

- Reducing duplication of data collection and storage;
- Providing faster distribution and processing of navigational information;
- Provide data to the mariner in near realtime; and
- Creating opportunities to develop a value added industry.

Network security measures should be taken to prevent unauthorised modification or destruction of the data.

7.6 SECURITY

Jackson (1990) defines security as the protection of information from unauthorized or accidental modification, destruction, disclosure and use. It must be stated that with computerisation, absolute protection is not possible and security should be considered as a form of risk management. Security measures are taken to reduce the probability and consequences of a security breach only if the cost is less than the damage likely to be incurred (Anderson, 1992).

Roitman (1988) describes information security as a function of hardware and software, data base structure, the communication network and administrative procedures. When dealing with information, security can be applied in two ways : system

security and data security. One might be tempted to believe that if system security measures are properly put in place then there is no need for data security since the data can only be accessed through the system. However, no system is perfect. It is important therefore to explicitly address data security rather than assuming that it will be attended to by system security (Anderson, 1992). In order to determine whether established

security measures are adequate, Halliden (1990) states that the information qualities of integrity, availability and confidentiality must be monitored.

7.6.1 Confidentiality

This is the state of being secret or known only to a select few. The system must provide confidentiality services to protect information against the threat of disclosure of the content of data travelling through the network or stored within attached computers. It should also have the ability to protect against disclosure of the origin, destination, volume and indeed the very existence of data travelling through the network.

7.6.2 Integrity

Parker (1991) describes integrity as the qualities of wholeness and completeness that exist in data. It refers to the situation where computerized data is the same as that in the source documents. It should be noted that data integrity has nothing to do with its accuracy. The system must have the ability of providing integrity services to protect the information against the threat of modification by unauthorized users.

In the situation where electronic chart updates are transmitted from one place to another (from HO to RECC or RECC to user), integrity services are important to ensure that the information

reaching the remote user is in a state of wholeness and unimpaired condition. Thus no parts of the information are missing, concatenated, encrypted or converted in unanticipated ways.

7.6.3 Availability

This is the ability of the system to ensure that data and other resources are at all times accessible to authorized users. This does not guarantee the accuracy or usability of the data or information. Unfortunately, availability is rarely included in formal security policies and is said to be the most ignored purpose of security with the exception of recovery planning and backup (Anderson, 1992). Data backup, redundancy planning and protection from physical harm are the principal means of implementing availability measures (Parker, 1991).

7.6.4 Accountability

This service is at the border between security and accounting. It goes beyond authentication in that it requires the system to hold some users or principal accountable for every action or event occurring in the system (Janson, 1994). It is essential for avoiding network abuse and repudiation, as well as in billing users for actual resource usage through proper accounting procedures. This can be used to keep a proper account of any HOs data sold by the RECC.

In a distributed environment, the security measures should address policy and technological issues such as identification, authentication, authorization, secure communications and auditing.

7.6.5 Security in a Distributed Environment

Providing security in a distributed environment is a bit complex. Rymer (1990) states that networks provide many data access paths, which are difficult to protect and greatly decrease the ability to effectively prevent intrusion. This is because in a distributed environment, the individual nodes are connected via a communication network and it requires a security strategy that recognises the issues associated with each of these two elements. The strategy should aim at addressing the security requirements of the communication links between the nodes. The success of any security controls ultimately depends upon how diligent they are implemented by the authorities at each node (Rymer, 1990).

Security at the nodes is achieved by the use of passwords and access control lists. This method aims at specifying which resources on the system are available to which users and to provide mechanisms to prevent those who are not authorized from performing certain activities.

In a distributed environment, free access to the entire system is gained if one breaches the security shield. It is important therefore that communication security be put in place to protect the links between nodes on the network. This could be achieved by checking user identities and privileges, encrypting data when necessary, and recording activities within the environment. All these activities are required to be carried out in an integrated, system-wide manner.

7.7 CHAPTER SUMMARY

The strategies for implementing the RECC include creating the awareness of change, achieving user and political cooperation, dealing with organisational conservativeness and developing the networks.

Security measures should be also put in place to weed out unauthorised users and to ensure the integrity of the data as it travels from one medium to another.

The proposed system should provide confidentiality services to protect the information against the threat of disclosure of content as it travels through the network. Also it must provide integrity services to protect the information against the threat of modification by unauthorised users. Accountability service is also necessary for proper accounting procedures. These security measures are important to limit the exposure of the Centre to legal liabilities.

CHAPTER EIGHT

8.0 LEGAL IMPLICATIONS OF A WORLDWIDE ELECTRONIC NAVIGATIONAL CHART DATA BASE

8.1 INTRODUCTION

Hydrographic Offices have been taken to various courts of justices for misleading or inaccurate charts. The courts have put the blame either on the quality of nautical documents or on the way they were used by the mariners concerned. Despite the inherent deficiencies in the hydrographic data, the hydrographic offices have rarely been considered to be responsible for accidents linked to the inadequacy or inaccuracy of the charts and other nautical documents. In most cases the charts or other nautical documents in use at the time of the accident are found to be inadequate or incorrect, but the liability of the issuing hydrographic offices has not been found. A number of groundings or strandings cases reported appear to have resulted from incorrect use of such documents by mariners, either by using charts in isolation or using an inappropriate scale (Pasquay, 1985). It appears that the mariner sometimes places excessive confidence in the charts.

Government and private individuals providing reliable information to the mariner must be aware of the legal responsibility and duties and the extent to which they may be liable for shipping casualties and other marine accidents. The reliance placed on charts and other nautical publications by the mariner exposes hydrographic offices (under the Crown Liability Act in the United Kingdom), to claim by ship and cargo owners for damages ranges up to millions of dollars based upon misleading or inaccurate charts (Troop, 1985). The liability would extend far beyond the HOs if a ship fitted with ECDIS meets with an accident.

All parties involved in the development and production of electronic chart data need to be aware of this responsibility and take all the necessary measures to protect and limit themselves from this potential exposure.

This section of the report examines the changes that may be brought about in the present legal system by ECDIS. Special reference is made to the legal problems associated with HOs sending data to RECC and the manner in which HOs, private producers, system designers and software developers can discharge their responsibilities and limit their liabilities. The legal problems associated with changing technology, new procedures and the updating of electronic charts and publications to meet future charting standards are discussed. Precautions to be taken to limit the exposure of the HOs and the RECC to legal liability is commented upon.

8.2 THE CHART

The chart has always been and will continue to be the product of the hydrographer's labour. Unlike maps, it shows the navigator what he cannot see. It reveals to him the shape and depth of the seabed. For all intents and purposes, the mariner has every right to put his faith in the chart to tell him where he can safely go and where he cannot since he has no other means of knowing. The chart must therefore be accurate and reliable.

8.3 THE CHANGING TECHNOLOGY

" The chart was, and still is, a document to be worked with and its development and use is directly related to the navigation techniques employed and there could be no review of the cartography without an appreciation of how position-fixing at sea was refined." (Martin, 1988)

In the past, soundings were obtained from leadlines which gave a limited coverage of the sea bed. Currently, multi-beam sounding techniques are used to give a greater coverage. The volume of information collected by modern instruments calls for a new technology. Modern survey techniques are gradually pushing the paper chart to a point where it is becoming less valuable for navigation. The paper chart will gradually give way to electronic charts which have information contents similar to but more detailed than the paper chart.

8.4 THE CURRENT SITUATION

The advancement in computer technology has moved the world from the industrial age to the information age. Today, digital data is rapidly becoming the most important format of exchanging and using information. It is used in conveying information in different forms and in completing tasks quickly and in some cases better than before. Digital data is used to portray the three-dimensional surface of the earth.

" The versatility of digital data will not only affect navigation but will touch every aspect of the chart-making process: gathering, assessing, interpreting, depicting and disseminating navigational information. We are now beginning to see digital data used to reproduce a traditional paper chart on a video screen, systems which integrate radar and other electronic data emanating for gear on board as well as from shore stations, and no doubt soon we will see as commonplace capabilities that automatically update electronic charts through such means as near realtime Notices to Mariners which update positioning information from satellites to give the navigator the most complete picture of the environment around him."
(Edward, 1990)

ECDIS will show the chart data in digital form. Its ability to integrate chart data with other nautical information has placed it in the limelight. The most exciting thing about this is the ANM which updates the chart without human intervention. The ship's antenna receives electronic data from the INMARSAT

satellite and automatically updates the information on display without degrading it. The mariner now sees the latest version of the chart. He will also see the true characteristics of navigational aids (eg. lights) instead of relying on descriptions in a publication or annotations on a chart. However, as the technology advances, new problems emerge which call for new policies and legal principles to ensure peace and order. Most people have expressed concern about the threat of the computer technology to their job security. To others, it is the national confidential information that is at stake.

Before looking at a few cases, let us examine the elements of the legal regime and outline the legal basis to which, under the present law, the chart maker is exposed.

8.5 ELEMENTS OF THE LEGAL REGIME

The elements of the legal regime which are of particular importance to the implementation of RECC include :

- Access, including questions of custodianship, royalty, privacy, copy right, and cost recovery.
- Liability, including questions of negligence, misuse of data and information and duty of care.

8.5.1 Access

" Access to personal and geographic information depends on law, economics and culture as well as technology. Law and the legal process determine the extent of disclosure or confidentiality of data and information." (Epstein, 1990)

Access is a fundamental issue in the development of ECDIS. The development of ECDIS alone cannot improve safety at sea unless there is an agreement or a policy which will allow the free flow of information from one hydrographic office to another. Information is valuable only when it becomes accessible to the user. However, having access to volumes of information alone will not solve the mariner's problem unless he knows and understands the short-comings of the information and applies proper procedures. Nautical information are divided and held among various hydrographic offices or countries. Epstein (1991) states that

" Transnational information access depends, in part, on the willingness of the nation to enter into international agreements. These agreements are necessarily a part of national foreign policy. They reflect the individual nation's perceptions of security, political, economic and social interests. Agreements in regard to transnational information flow depend upon a balance of national and internal interest. The flow of information can become part of the international flow of commerce, but it can also reflect a concern about confidentiality of personal data, national economy and security. Each nation is likely to attain its values to the integrity of information about its own activities."

Access to information is the most pressing issue in a distributing information environment and deserves appropriate analysis. Computers provide a powerful means of analyzing data which may results in the invasion of privacy.

8.5.2 Copyright

Although the purpose of ENC is for safe navigation, it could be used for military purposes against the information provider. To prevent such and other occurrences (misuse of information), while ensuring availability of information, it is necessary to exercise some form of ownership right. Copyright is one legal principle which could be used to address or prevent such situations. According to Anderson (1992) section 3(1) of the Canadian

Copyright Act of 1985 defines Copyright as " the sole right to produce or reproduce the work or any substantial part thereof in any material form whatever". Copyright protects artistic and literary works. Artistic works include charts, plans paintings drawings etc.. Literary works include tables, compilations, translations and computer programs.

Ownership of copyright does not necessary follow the physical ownership of the work. What is protected is the form of expression of the work and not the idea, concept or subject matter of the work. Burshtein (1987) states that copyright affords a narrower protection of right than a patent in that it only provides for protection against copying, not against independent creation. According to Dando (1991) facts cannot be copyrighted but compilations of facts can. This implies that data bases being a compilations of facts can be copyrighted. Anderson (1992) states that copyright protects specific presentation of the data but not the data or facts themselves. Copyright can only subsist in a work if the work exists in some form susceptible to being copied.

The WEND conceptual model requires HOs that are not technically capable of providing digital data to send their paper charts to their respective RECCs for capturing. The ownership of copyright may be difficult to determine under such conditions. It is not clear at this stage whether the RECC will capture the data under a "contract of service" or a "contract for services". If the RECC does the data capturing under a "contract of service" then the ownership of the copyright may belong to the HO. But if the work is done under a "contract for services" then the RECC will have the ownership if there is no agreement to the contract.

Another important issue is the creation of a seamless data base from the HOs data base by the RECC. In such situations who owns the copyright of the composite data base ? Is it the individual

HOs or the RECC ? Common opinion expressed regarding compilations states that if sufficient effort has gone into creating a new data base, then copyright has not been breached.

" Where data entered into a public or private sector agency data base has been derived from a range of documents, and employees have applied a significant measure of skills, ingenuity, experience and labour to originate a new product (a computer-based land information data base), there is considerable justification for a claim that these data bases are literary works within the context of the Copyright Act and that the copyright which subsists in them is vested in the constructing agency." (ALIC, 1990b)

For an integrated data base, copyright may subsist in the integration as a whole and be owned by the RECC. However, for copyright to subsist in the integration as a whole, the RECC must seek permission from the individual HOs for the use of the individual data bases. Copyright may be retained for the separate data bases by the HOs. ALIC (1990b) states that for electronic or digital data, the amount of skill, ingenuity and labour required to create the compilation may be significantly decreased and the ownership of copyright may be open to question.

8.5.3 Custodianship

This term is used when dealing with corporate a information resource. It is the collection and management of data by an organisation on behalf of the wider community. The custodian does not own the data but holds it to provide effective management of the data. The custodian has some responsibilities and is entitled to certain rights (ALIC, 1990a).

The RECC will be a custodian holding data on behalf of other HOs in an attempt to provide effective data management. Certain responsibilities will be assumed by the RECC and will be entitled to certain rights with respect to the data. The RECC will be responsible for quality control and assurances, data content and formats, validation and maintenance as well as the principles and

procedures for accuracy, currency, data storage and security. In return for the services rendered by the RECC, it will charge users of ENC, licence users and distribution agents and market the data in a way the HO would.

In order to control the use of the data, Member States should agree on the terms and conditions under which the ENC may be used and who should have access to the data. The responsibilities and rights of the custodian (RECC) should be agreed upon before supplying data to the RECC. Oil and other companies may also make use of the information. The information may be used to create or add value to a product. If the value added product is sold to a third party, how can the HO gain proper compensation for its use? Anderson (1992) states that the best measure is by licensing agreements rather than relying on copyright.

Another important concept is royalty. "Royalty is the monetary consideration received by the owner of copyright in a work from a person for a licence to make copies of the work" (ALIC, 1990b). When dealing with electronic data, the term "licence fee" is used in place of royalty. A licence fee gives an indication that the user of ENC is not the owner but has been granted permission to use the data. It may include a contribution towards data conversion, maintenance, and material cost. According to ALIC (1990b) any licence or agreement should include the following terms and conditions:

- the requirement for a licence fee;
- term (time period) of data delivery;
- intellectual property indemnity;
- limitation of liability;
- disclaimer and release;
- confidentiality between department and client;
- verification of proper data use;
- security control of data in the licensee's control
- indemnity for modifications by the licensee;
- data update; and

- schedules, which include statements about the equipment needed to use the data, the format of the data, storage media, and other documentation.

8.5.4 Privacy

The advent of electronic computers are making the development of distributed information systems a reality. The computer technology provides a new and powerful means of gathering, processing and distributing information products. However, many people have expressed concern about the threat of the technology to their privacy.

The right to privacy is recognized by social scientists as essential for the preservation of an individual's human dignity including his physical, psychological and spiritual well-being (Mcquoid, 1978). Over the past few decades, privacy has been threatened by developments in technology and the mass media which are common features of modern society. One of the greatest threats to the privacy of a nation is the use of the computer for the collection and processing of data concerning the nation. This is due to the ease with which information may be obtained, analyzed and disseminated. The main fear is that national confidential information may be accessed, resulting in the invasion of privacy. Much of the information available today has always been available. However, the advent of electronic computers have made the accessibility and use of these records much easier.

Paper maps and charts used in the past, provided some form of protection from invasion of privacy due to their scattered and poorly documented nature. It was difficult not only to retrieve and be certain that all available information had been retrieved but also to effectively analyze the information. Absolute control over information becomes more difficult as computer networks create new ways of obtaining and analyzing information about a

country. Confidential information such as acoustic shadow areas could easily be derived from digital temperature, depth and salinity data of interest to submariners with hostile intent. Composite profiles of a country can be created by linking information from selected data bases. The compilation of the data, however, may reveal more about the country than was intended, or may create information for which consent was never obtained. The information content of certain data bases, after selective combination and analysis may be greater than the sum of the parts (Nickel, 1989).

Mcquoid (1978) pointed out that the implications for computers for privacy are that they (a) facilitate the maintenance and retention of extensive records; (b) make data easily and quickly accessible from many distant points; (c) make it possible for data to be transferred quickly from different systems; (d) make it possible to combine data in ways otherwise not practical; and (e) allow data to be stored, processed and transmitted in unintelligible forms, so that few people know what is in the records and what is happening in them. The combination of the above factors may expose the subject of the information profile to the danger that the information (a) is inaccurate, incomplete or irrelevant; (b) may be given to persons who should not or need not have it; and (c) may be used for some purpose other than that for which it was collected.

As long as information is stored in computers we can never be sure of any guarantee to privacy (Linden, 1988). It is important therefore that steps be taken to ensure that the ENC data is used for the intended purpose to prevent invasion of privacy.

8.5.5 Liability

Legal liability may be based either on contract or in tort. In contract, the liability will arise if there is an agreement to supply an accurate chart and the supplier provides an inaccurate one. The other person can then claim there has been breach of contract and can sue the supplier of the chart for any damages resulting from the breach. Those who design and operate information systems are not exempted from these concerns (Epstein and Roitman 1987).

Liability in tort arises where a person causes another to suffer civil injuries or damages. These include circumstances where, for instance, a motor vehicle owner knocks down a person who thereby sustains bodily injuries, or where somebody's nuisance or negligence case another to suffer injuries or damages. Unlike contract, there is no agreement in tort. The software developer for instance, may not have any agreement with the mariner. However, he may be liable if the mariner sustains injuries or damages as a result of his negligence. Tort therefore regulates liabilities which arise in the normal intercourse between juristic entities.

8.5.6 Product Liability

This is the legal principle that imposes a liability on anyone who sells products in a defective condition. Under strict product liability, it is not necessary to show that the manufacturer of the product was at fault, just that the product was of an inherently dangerous nature and in fact caused harm.

This legal principle may develop in the maritime industry with the implementation of RECC or WEND. Any hydrographic office or supplier who supplies or sells defective charts may be held liable under this. The system designer or software developer of

ECDIS may also be liable under this principle if the system or software fails to display ECDIS data in accordance with the IHO's specifications.

Under this principle, a manufacturer of a product may bear some or all the liabilities if his products are found to be defective. In producing the EC data, one should not confuse the accuracy of the data with its integrity or reliability. The electronic chart may be accurate as to its content, but defective for some other reason. If the user sustains injury from the use of such products, the manufacturer, coordinator and the supplier may be jointly held liable. The traditional defence that the chart correctly portrayed the information provided by the government may not be sufficient to avoid liability if, for instance, it is shown that its design, ie scale, graphics, symbology, etc., misled the navigator (Edward, 1990).

8.5.7 Duty of Care and Third Party Liability

This is a legal principle that places a responsibility on a professional. The Hydrographer owes the mariner a duty of care. This is because he knows that the mariner will base his activities on the assumption that the information supplied to him is correct. As we enter into the digital age, the number of people who will owe the mariner a duty of care will increase. According to Anderson (1992) duty of care which used to be applicable to professionals and their clients and employees, has now been expanded to apply to any information provider.

Campbell (1980) states that in order to prove that an information provider is liable to a third party, the following questions should be answered:

- did the information provider breach the standard of care expected of a person in that position ?

- was the plaintiff's reliance on the information reasonable in the circumstances ?
- is the plaintiff a member of the class of persons to whom the defendant owes a duty of care ?
- did the plaintiff's reliance on the information result in damages ?.

Other users of the ENC should be mindful of this legal principle and Member States and RECC should agree on the class of persons to whom they will owe a duty of care.

8.5.8 Negligence

Negligence arises when a person fails to exercise the standard of reasonable care normally expected of a person in that situation and some damage to another person occurs as a result of that failure. Courts and legislatures have defined "reasonable care" for many situations. Chart makers are often covered by this type of standard. The chart maker being a professional is expected by law to exercise the skill and competence of an ordinarily competent chart maker.

To succeed in cases of negligence, the chart-user must establish that;

- he relied on the accuracy of the chart;
- the chart was inaccurate or misleading;
- the chart was inaccurate because the chart maker or hydrographer was careless; and
- the damage claimed was caused by that inaccuracy and not by an error of navigation.

8.6 CASES

In this section, the report looks at a few cases involving the nautical chart and how the courts dealt with them. It also examines how some of the accidents could have been avoided by ECDIS. Special reference is made to the way and manner the elements of the legal regime has been applied by the courts.

AETNA Casualty & Security Co. v Jeppeson & Co.

In the court action (AETNA Casualty & Security Co. v Jeppeson & Co. 1981), the court found Jeppeson & Co. liable for the fatal plane crash which resulted from a defective aeronautical chart published by Jeppeson. Jeppeson depicted on the chart the instrument approach to an airport from tabular information they obtained from the Federal Aviation Administration (FAA). The procedure included all pertinent aspects of the approach such as directional headings, distances, minimum altitudes, turns, radio frequencies, etc.. The court held that Jeppeson was strictly

liable for injuries caused by the defective product because a change in scale between charts would not be readily apparent to the pilot.

Comments

The chart published by Jeppeson was accurate in content but defective in scale. The court did not find any fault with Jeppeson. However, they were liable because their product was defective in some sense and in fact caused the accident. The product liability principle was applied in this case.

The case of the PIONEER COMMANDER

On 13th August 1973, the ship PIONEER COMMANDER of the United States Lines went aground near the Clettack Skerry at the entrance of Pentland Firth when returning from Bremerhaven to Bayonne via the north of Scotland and the Orkneys.

The ship's owner took the Defence Mapping Agency (DMA) to court for inaccuracy in the description in their list of lights of the Pentland Skerries Light. The list of lights showed the following sequence for the light in question:

" flash 0.4s - eclipse 0.1s - flash 0.4s - eclipse 0.1s - flash 0.4s - eclipse 28.6s "

instead of the sequence :

" flash 0.4s - eclipse 5.6s - flash 0.4s - eclipse 5.6s - flash 0.4s - eclipse 17.6s ".

The South District Court of New York dismissed the claim by the owner on the grounds the mistake in the list of lights did not contribute to the stranding. The court found the PIONEER COMMANDER to be unseaworthy for the following reasons:

- the vessel did not use, or did not carry on board, charts that were adequate for the approach to and navigation through Pentland Firth.
- the radar was not sufficiently reliable because of frequent breakdowns.

According to the court, the captain and the officer-on-watch were negligent in that they did not use all the aids to navigation they had at their disposal (DECCA for the approach to Pentland Firth, because of lack of the chart carrying the corresponding lattices, the radio direction finder, sounder). The court also ruled that they did not take the necessary action in order to keep at a prudent distance from known charted dangers.

Comments

The PIONEER COMMANDER used DMA chart No. 35010 (scale 1/356 000). DMA charts covering the Pentland Firth include chart No. 35120 (scale 1/137 000) and chart No. 35141 (scale 1/50 000). The latter was on board but was not on the bridge at the time of the accident. The chart used by the PIONEER COMMANDER did not carry a warning inviting the mariner to refer to charts on a larger scale and carrying an index showing the limits of those charts. The mariner used one chart in isolation.

The Sailing Directions on board the ship were published in 1950 and updated to 1966 the validity of which had expired in 1976. The description of the light had been incorrect since 1958 and numerous mariners had certainly sailed through Pentland Firth during those years. This anomaly had not been reported until two months after the accident. In fact the information was given not in the interest of safe navigation but in order to win the legal proceedings.

It is important to note that pointing to errors on the chart can not be substituted for prudent navigation. If the ship were to be using an ECDIS system, the mariner would have been alerted by the characteristics of the lights. Either the chart would have flashed a warning that the light was in error or when attempting to display, it would have given an error message regarding the list of lights.

With the EC technology, the mariner will have a system which integrates all the necessary data and display that on the ECDIS display. However, the legal standards of "reasonable and prudent navigation and seaworthiness" will change, but how and to what degree may depend upon the courts. Clearly, one can see that ship owners will have to equip their vessels with some minimum digital capabilities and the mariners will be required to understand the full capabilities of the integrated system.

The accident caused by the dredge MAUREPAS

The Facts

The Southern Natural Gas Company (S.N.G.) was granted three permits by the United States Army Corps of Engineers to construct three underwater gas pipe lines buried three feet below the mudline in Lake Pontchartrain in Louisiana. In error the Army Corps of Engineers communicated this to the Coast Guards instead of the National Ocean Service which is responsible for official charts of U.S. waters. Army Corps of Engineers disclosed on the chart the information relating to a single pipeline referred to in the first permit. They mistakenly assumed that dredging was prohibited by decree of a local commission and so did not prohibit dredging in the vicinity of all the S.N.G. pipelines. During a dredging operation in 1979, the dredge MAUREPAS struck one of the pipelines and caused it to burst. Several people were hurt and the MAUREPAS was damaged.

The Findings

The Eastern District Court of Louisiana ruled that the government was partially liable for the accident. The court also ruled that the National Ocean Service (NOS) had been negligent in showing only one of the three pipelines on its chart. The fact that they depicted one gas pipeline on the chart obliged them to show all of them, since the mariner seeing one gas pipeline charted, was justified in supposing that the charting of gas pipelines was complete. The court concluded that the "precautionary note" on the chart referred only to the incomplete portrayal of oil pipelines and not to the charting of gas pipelines.

The court ruled that there was an obligation to show the pipelines since the N.G.S pipelines were three feet below mudline and dredging is normally carried out up to six feet below mudline. The court realised that the second-in-command,

responsible for the MAUREPAS, did not consult the chart prior to the accident. However, the court insisted that the fact that NOS had shown one gas pipeline instead of all the three on the chart, and had shown it in an erroneous position was one of the causes of the accident.

Comments

In this case it was shown that the damages claimed were caused by the inaccuracy and not by an error of navigation.

The case of the tanker TESIS

The Facts

In 1977 the Soviet tanker TESIS, navigating in a narrow natural fairway heading for Södertälje, struck a rock at a depth of six metres, about a hundred metres from a skerry called the Käringsklubb on the eastern coast of Sweden. The rock was not shown on the Swedish chart No. 721 (scale 1/50 000) which portrays the fairway. The rock was about two millimetres from the skerry at the scale of the chart.

The Findings

In 1840, a rock was discovered in the neighbourhood of the Käringsklubb at a depth of eight metres. The rock was found again during a subsequent survey between 1918 and 1921. A third survey carried out in 1969 found a rock at a depth of six metres in the same area.

The officer responsible for the 1969 survey had judged that the rock discovered was " inside " the ten-metre depth contour on the chart in use, and that there was no need to report it. A survey

carried out after the accident in 1977 showed that the ten metres depth contour on the chart 721 was slightly in error and should be moved about 20 metres, i.e. 0.4mm on the scale of the chart. It was said that the TSESIS pilot began the "S"-shaped turn for navigating between the Käringsklubb and the Fifong island earlier than was usually the case. As such, the TSESIS passed closer to the Käringsklubb than do vessels normally piloted through these waters.

The Judgements

The District Court of Stockholm ruled that the officer-in-charge of the 1969 survey was negligent for not informing the pilot station and the Hydrographic Office of the discovery of the rock in question. It also ruled that the pilot and the ship's captain had navigated negligently in sailing too close to the Käringsklubb. The court blamed the pilot and the captain for not taking account of the fact that a slight error in the position of depth contours is always possible.

The owners invoked Article III 2c of the 1969 International Convention on Civil Liability for Oil Pollution Damage and submitted that the chart was a navigational aid. However, under the terms of that convention, "no liability for pollution damage shall be attached to the owner if he proves that the damage was wholly caused by the negligence.. of the .. authority responsible for the maintenance of lights or other navigational aids..." The owners claim was dismissed by the court on the grounds that the chart is not a navigational aid.

The case went before the appeal court. The court concluded that the officer-in-charge of the 1969 survey was negligent but did not find any error of navigation. However, it confirmed that the nautical chart was not a navigational aid under the terms of the 1969 convention.

The Supreme Court considered that, in the absence of information leading him to doubt the accuracy of the information on the chart, it was quite reasonable for the pilot to sail as close to the Kåringklubb as he did. It also recognised that it was difficult to keep a tanker exactly on track; deviations from its intended course of some ten or twenty metres to either side are always possible. It concluded that the pilot and the captain were not to be blamed. The court ruled that the officer-in-charge of the survey had committed an error in not obeying the instructions which prescribed that he should report any discovery of a new shoal dangerous to navigation.

Comments

The ruling by the District Court stressed the limitations inherent in nautical charts which the mariner must take into account. The uncertain effects of wind, weather, tide and unpredictable casualties are adverse to the idea that the admiralty charts are intended to constitute a standing offer carrying a warranty that the ships entering the charted port will find the same conditions as those indicated on the charts (Troop, 1983). Charts represent conditions at the time of survey. The user should not assume that the chart contains no error or omission. For it is not possible to guarantee that nothing escaped the hydrographer's investigation.

The fact that the sea bed is liable to change and that a certain amount of time elapses between the moment when the change takes place and the time when the hydrographer receives the information and brings the change to mariners' attention gives an indication that the chart can never be perfect. The mariner should not forget these shortcomings of hydrographic data and navigate with care. Hydrographic offices should no doubt take the precaution of stipulating that granting authorization to reproduce or borrow information from their charts can imply no liability on their part (Pasquay, 1985).

The prudent mariner must not "cut things too fine" by navigating too close to the curves separating a danger area from one where navigation is possible. It also asserted that any danger to navigation of which a hydrographic office is aware must be made known to mariners.

One must not forget that in spite of all the excitement being made about the electronic charts, it is the same traditional charts which have been digitized. It is important that HOs make the ENC updates available to the mariner at the earliest possible time.

8.7 PROBABLE CHANGES IN THE LAW

Some hydrographic offices are more equipped than others. While some are currently equipped to transmit automatic updates to mariners, others have to depend on the semi-automatic and the present system for the next few decades.

The concepts of ECDIS is still very young. Various IHO/IMO committees are working to standardize the formats of the data bases, hardware and software systems that manipulate the data base etc. These standardization processes will continuously affect the development and capabilities of ECDIS. The capabilities of this new technology have the potential to improve safety and hydrographic services.

The EC may not change the basic legal standards concerning the liability for negligent charting. However, the capabilities of ECDIS may in future change the standards of liability as it currently exists regarding negligent charting, prudent navigation and vessel seaworthiness.

The system designer and the software developer will be held to the same duty of care as exists presently. Thus when the system fails to display information in the correct format or the software functions fail to process data as expected, they will be held liable. ENC coordinators, HO's and suppliers will be held to the same duty of care for supplying accurate data bases for ECDIS. As to how the mariner or the court will determine what level of data base accuracy is required of the HO or RECC is left for future litigation.

One major problem is the transfer of ENC updates on the network. The paper chart is fixed as to its content and any changes by the user is obvious. The nature of computer data exposes it to intentional or unintentional manipulation by users and intruders. Provision has been made to avoid the alteration of ENC data and updates by the mariner. However, an intruder can manipulate the ENC updates being transported on a network from one HO to another. There is therefore the need for high security measures on the network to weed out any such intruders. The fact that ENC data and updates may be exchanged between hydrographic offices (from HO to RECC) through the Inter-net or WAN may raise new and interesting legal issues.

8.8 LIMITING LIABILITY

Maritime accidents involve millions of dollars. As such no one wants to hear of them. It is important that all efforts be taken to limit the liability of the RECC and the HOs. Ideally one may think about producing error free charts. Unfortunately, the hydrographic data itself have some shortcomings and as such cannot be error free. The best option is to minimize errors or reduce them to an acceptable level. All parties involved in the production of ENC should take maximum precautions when discharging their duties. Epstein and Roitman (1987) and Salmon (1989) suggested several ways by which risk of liability can be reduced.

- Carefully selecting and maintaining the computer hardware and software will reduce the risk of liability. The system owner or operator must ensure that the system is capable of carrying out the tasks for which it is intended to.
- The quality of data in the data base must be good enough to meet the user's requirements. Details of timeliness, scales, completeness, precision, source and age of data, context of collection etc. must be made available to all users of the ENC. This is to enable the users to determine whether the quality and quantity of the data is sufficient for his intended use.
- Data entry techniques must be adequate. The techniques must ensure low level of errors. Quality control, assurance and error correction mechanisms must be put in place.
- Data and system security should be ensured. The data and system must be protected from unauthorized users. Access to the system by clients and other RECCs should be controlled by contractual arrangement. There is also the need for contingency planning to avoid loss or damage which may occur if the system fails.

8.9 CHAPTER SUMMARY

In the cases studies provided, nautical documents and charts have been accused rightly or wrongly. Most of the verdicts proved that the HOs were not liable, not because the charts are error free but because the plaintiffs could not prove that the imperfection of the nautical chart was the sole cause of the accidents. In many cases it was clear that the cause of the accident was due to the incompetence or negligence of the mariner.

The hydrographic office cannot be sued if any danger to navigation to which the HO is aware is made known to the mariner on time. If a claim of damages is to be admissible to the court, the chart user must be able to show that :

- he relied on the accuracy of the chart;
- the chart was inaccurate or misleading;
- the chart was inaccurate because the chart maker or hydrographer was careless; and
- the damages claimed were caused by that inaccuracy and not by an error of navigation.

Copyright alone cannot provide an acceptable level of control over ENC. This is particularly true when data bases are compiled from a variety of HOs. To avoid confusion and misunderstanding, contractual agreements should be used to clarify all doubts.

Some of the accidents could have been avoided if the ships were fitted with ECDIS equipment. ECDIS will integrate chart data with other nautical information. The mariner can display the chart data at different scales. However, they should be encouraged to use the chart scale appropriate to the area in which they navigate. Mariners should know and understand the shortcomings of the hydrographic data and apply it accordingly. The system designer, software developer, the hydrographer and all parties involved with the production of EC data may be liable for a maritime accident involving ships fitted with ECDIS. There is the need for security measures if ENC updates are to be transmitted on a network.

CHAPTER NINE

9. CONCLUSION

The long-awaited new technology for mariners is now here. The ENC technology will replace the traditional paper chart and improve safety at sea. However, for the ENC to replace the paper chart, its content and structure should be standardised and complete as the current form of the paper chart. Unlike the paper chart, the EC will remove clutter from the screen by selecting and displaying information necessary at a particular moment. All ships that are not fitted with ECDIS equipment will still be required to carry on board the traditional paper charts.

The basic requirement for ECDIS is to integrate the traditional paper chart and other navigational information necessary for safe navigation. A system can qualify as an ECDIS only if it can display all the SENC information. The functions of ECDIS include route planning and monitoring. During route monitoring, the system will be required to present only the immediate relevant information in a clearly and unambiguous manner. The system should give an alarm if within a specified time set, the ship crosses a safety contour or the boundary of prohibited area.

The special committee on WEND has approved the proposal to establish and implement WEND on a regional basis. The conceptual organisational model requires Member States to send their data to their respective RECCs for distribution to international shipping. Member States are encouraged not to compete in providing services to the mariner. The need to avoid duplication of effort has been emphasized and it is believed that Member States will adhere to those principles as listed in Appendix 3A. Member States will be paid for the data sent to the RECC, the amount depending upon a mutual agreement between the RECC and the HO.

Factors that need to be considered when designing the infrastructure for the RECC include data problems, security measures, institutional and technological issues. Institutional issues to be considered include ownership and responsibilities. Technological issues include networking and distributed systems as well as data and network security measures.

The infrastructure component should consist of data collection systems, data bases, data transmission systems and security measures to weed out unauthorized users. The legal principle, "duty of care", which used to be applicable to professionals and their clients has now been extended to include information providers. Copyright alone cannot provide an acceptable level of control over ENC. Contractual arrangements should be used where necessary to clarify all doubts. Hydrographic offices cannot be sued if any danger to navigation to which the HO is aware is made known to the mariner on time.

Ways of limiting the exposure of the RECC to liability include carefully selecting and maintaining computer hardware and software, making details of timeliness, scales, completeness, precision and age of data available to all users of ENC.

9.1 RECOMMENDATIONS

Sub-Saharan Africa has three countries which are members of the IHO (Member States). They are Nigeria, Zaire, and South Africa, all with well-established hydrographic offices, as also has the Malagasy Republic. Geographically, South Africa is at the centre of the sub-Saharan African states, with ports strategically positioned and used by ships enroute from America and Europe to the Indian Ocean and the east.

The success of any future RECC will depend on the willingness of Member States to work together in developing data bases for ECDIS. Other countries such as Ghana, Ivory Coast, the Malagasy

Republic etc., with observer status in IHO, must also be willing to contribute data to the RECC. Organisational, institutional and technological issues need to be addressed to get all sub-Saharan African states involved. The recommendation for implementation of RECC has been broken down into three categories : organisational; operational; and research and development.

9.1.1 Organisational Recommendations

- A committee should be set up to assess the status of existing data in various hydrographic offices to determine:
 - the format of the data;
 - areas which need to be re-surveyed;
 - the suitability of the data for ECDIS application: Those areas not yet suitable should remain on existing paper chart procedures;
 - the level of availability of data;
 - geographical areas covered; and
 - future possible users of ENC.

- A seminar or workshop on ECDIS should be organised for mariners, fishermen and politicians to create the awareness of the potential of ECDIS for safe navigation.

- A committee involving politicians from various countries should be formed to steer the affairs of the implementation process.

- Currently, South Africa is the only African state serving on the Committee on ECDIS (COE). The hydrographic office in South Africa has not been under such great colonial influence as others on the continent and is autonomous. South Africa has embarked on various hydrographic projects with the aim of producing ECDIS data within the next two years (WEND Committee's report, 1995). Almost all the

traditional published paper charts have now been digitized. The hydrographic office in South Africa is in fact a training ground for some African States. Malagasy, for example, sometimes sends people to South Africa to study various hydrographic techniques which include data acquisition and compilation.

South Africa is well-suited to serve as a regional centre for sub-Saharan Africa. It is technologically and economically competent in executing and financing the task as a Regional Centre for sub-Saharan Africa. Most of the required infrastructure is already in place and other states should send their data to South Africa for packaging and transmission to the mariner.

9.1.2 Operational Recommendations

- The network should be implemented by first building a Directory of Marine Information. The DMI should contain the information listed in page 73. It should also contain information about other RECCs. The network should be connected to all sub-Saharan African States which can supply chart data in digital form and to other RECCs.
- Existing paper charts and other hard copy navigational information should be converted into electronic format. Countries that are not technically competent in producing digital data should send their paper charts and other hard copy navigational information to the RECC for processing.
- Local mariners should be trained and given time to adjust to the new technology (ECDIS).
- Staff development programmes should be embarked upon to improve the capabilities of staff in meeting this new and exciting challenge ahead.

9.1.3 Research and Development

- Research should be undertaken to determine the use of expert systems and artificial intelligence in support of distributed systems.
- Research should be undertaken to determine the standards of protocols in telecommunications systems, data models, data base management systems and networking systems to be implemented to ensure compatibility of the systems and improved services to the mariner.
- Research is required in the actual design and format of the system to be implemented.

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APPENDIX 2

SENC INFORMATION AVAILABLE FOR DISPLAY DURING ROUTE PLANNING AND ROUTE MONITORING

IHO, (1993). *Specifications for Chart Content and Display Aspects of ECDIS*. Special Publication No 52, Third Edition, October, 23 pages.

APPENDIX 2A

STANDARD DISPLAY : ECDIS display of information requirements.

Standard Display, to be displayed when the chart is first displayed by ECDIS, consisting of :

- 1 Display Base;
- 2 drying line;
- 3 indication of fixed and floating aids to navigation;
- 4 boundaries of fairways, channels etc.;
- 5 visual and radar conspicuous features;
- 6 prohibited and restricted areas;
- 7 chart scale boundaries; and
- 8 indication of cautionary notes.

APPENDIX 2B

DISPLAY BASE : ECDIS display of information requirements.

- 1 Display Base, permanently retained on the ECDIS display, consisting of :
 1. coastline (high water);
 - 2 own ship's safety contour, to be selected by the mariner;
 - 3 indication of isolated underwater dangers of depths less than the safety contour which lie within the safe waters defined by the safety contour;
 - 4 indication of isolated dangers which lie within the safe water defined by the safety contour such as bridges, overhead wires, etc., and including buoys and beacons whether or not these are being used as aid to navigation;
 - 5 traffic routing systems;
 - 6 scale, range, orientation and display mode; and
 - 7 units of depth and height.

APPENDIX 2C

NAVIGATIONAL ELEMENTS AND PARAMETERS : ECDIS display of information requirements.

- 1 Own ship;
- 2.1 past track with time marks for primary track;
- 2.2 past track with time marks for secondary track;
- 3 Vector for course and speed made good;
- 4 Variable range marker and/or electronic bearing line;
- 5 Cursor;
- 6 Event;
- 7.1 Dead reckoning position and time (DR);
- 7.2 Estimated position and time (EP);
- 8 Fix and time;
- 9 Position line and time;
- 10 Transferred position line and time;
- 11.1 Predicted tidal stream or current vector with effective time and strength (in box);
- 11.2 Actual tidal stream or current vector with effective time and strength (in box);
- 12 Danger highlight;
- 13 Clearing line;
- 14 Planned course and speed to make good (Speed is shown in box);
- 15 Waypoint;
- 16 Distance to run;
- 17 Planned position with date and time;
- 18 Visual limits of lights arc to show rising/dipping range; and
- 19 Position and time of "wheelover".

APPENDIX 2D

AREAS FOR WHICH SPECIAL CONDITIONS EXIST : ECDIS requirements for route monitoring.

The following are the areas which ECDIS should detect and provide an alarm or indication when appropriate :

- Traffic separation zone;
- Traffic routing scheme crossing or roundabout;
- Traffic routing scheme precautionary area;
- Two-way traffic route;
- Deepwater route;
- Recommended traffic lane;
- Inshore traffic zone;
- Fairway;
- Restricted area;
- Caution area;
- Offshore production area;
- Areas to be avoided;
- Military practise area;
- Seaplane landing area;
- Submarine transit lane;
- Ice area;
- Channel;
- Fishing ground;
- Fishing prohibited;
- Pipeline area;
- Cable area;
- Anchorage area;
- Anchorage prohibited;
- Dumping ground;
- Spoil ground;
- Dredged area;
- Cargo transshipment area;
- Incineration area; and
- Specially protected areas.

APPENDIX 2E

OTHER INFORMATION : The SENC information which is not part of the standard display.

All other information displayed individually on demand:

- 1 spot soundings;
- 2 submarine cables and pipelines;
- 3 ferry routes;
- 4 details of all isolated dangers;
- 5 details of aids to navigation;
- 6 contents of cautionary notes;
- 7 ENC edition date;
- 8 geodetic datum;
- 9 magnetic variation;
- 10 graticule; and
- 11 place names.

APPENDIX 3

EXTRACT FROM DRAFT REPORT OF THE SPECIAL COMMITTEE ON WEND.

**SPECIAL COMMITTEE ON WEND WORLDWIDE ELECTRONIC NAVIGATIONAL CHART
DATA BASE (WEND)PRINCIPLES**

IHO, (1994). *Draft Report of the Special Committee on WEND.*

Appendix 3A

EXTRACT FROM DRAFT REPORT OF THE SPECIAL COMMITTEE ON WEND.

LIST OF PRINCIPLES

OWNERSHIP AND RESPONSIBILITY

- 1 (a) A Member State has responsibility for preparation and provision of digital data and its subsequent updating of its own national waters.
 - b) The Member State responsible for originating the data should validate it.
 - c) A Member State responsible for any subsequent integration of a country's data into a regional, or larger, data base is responsible for validating the results of that integration.
 - d) Responsibility for providing digital data outside areas of national jurisdiction should be established.
 - e) The INT chart system is a useful basis for areal selection.
 - f) Legal liability must be recognized by participants.
-
- 2 (a) In the interests of safety at sea and to respond to the increasing demand for ENC, Member States are encouraged to work together in establishing and maintaining a WEND system as soon as possible, to share in common experience and reduce expenditure, and to ensure the greatest possible standardization and reliability.
 - b) Terms of Cooperation Arrangement of January 1992 (see IHO Circular Letter 23/1992) may be useful in arranging transactions between data base organisations and national HOs.
 - c) HOs are strongly recommended to provide data to HO data base organisations pursuing data bases within the WEND concept.

- d) Member States are encouraged to work together on data capture or management.
- e) Neighbouring Member States are encouraged to cooperate in boundary areas.
- f) Advantage should be taken to share all experience gained.
- g) Member States planning to incorporate data that must be obtained from another Member State into an integrated data base should inform those countries well in advance.
- h) The development of overlapping data sets from different sources should be avoided if possible.

Appendix 3B

EXTRACT FROM THE INTERNATIONAL HYDROGRAPHIC REVIEW.

MEMBERS OF THE IHO : The countries below are the Member States of the IHO.

- ARGENTINA
- AUSTRALIA
- BELGIUM
- BRAZIL
- CANADA
- CHILE
- CHINA
- CUBA
- CYPRUS
- DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA
- DENMARK
- DOMINICAN REPUBLIC
- ECUADOR
- EGYPT
- FIJI
- FINLAND
- FRANCE
- GERMANY
- GREECE
- GUATEMALA
- ICELAND
- INDIA
- ITALY
- JAPAN
- MALAYSIA
- MONACO
- NETHERLANDS
- NEW ZEALAND
- NIGERIA
- NORWAY

- OMAN
- PAKISTAN
- PAPUA NEW GUINEA
- PERU
- PHILIPPINES
- POLAND
- PORTUGAL
- REPUBLIC OF KOREA
- REPUBLIC OF SOUTH AFRICA
- SINGAPORE
- SPAIN
- SRI LANKA
- SURINAME
- SWEDEN
- SYRIAN ARAB REPUBLIC
- THAILAND
- TRINIDAD AND TOBAGO
- TURKEY
- UNION OF SOVIET SOCIALIST REPUBLIC
- UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
- UNITED STATES OF AMERICA
- URUGUAY
- VENEZUELA
- YUGOSLAVIA
- ZAIRE

GLOSSARY AND ACRONYMS

Unless otherwise stated the glossary and acronyms below were obtained from the Glossary of ECDIS-Related Terms (IHO, 1993).

ACCURACY : The extent to which a measured or enumerated value agrees with the assumed or accepted value. Not to be confused with precision.

AIDS TO NAVIGATION: Visual, acoustical or radio device external to a craft designed to assist in the determination of a safe course or of a vessel's position, or to warn of dangers and obstructions.

ALARM : Audible or visual means of announcing a condition requiring attention.

ALL OTHER INFORMATION : Term used in the Draft Performance Standard for ECDIS to describe information not belonging to the Standard Display. Also sometimes called " on-demand information".

AUTOMATIC CHART CORRECTION: A correction applied to an ENC in a machine readable form so that no operator interaction is involved.

AUTOMATIC RADAR PLOTTING AID(ARPA): A system wherein radar targets are automatically acquired and tracked and collision situations computer-assessed and warnings given.

CELL UPDATE: An updating method by which the content of an entire cell is replaced by new data.

CELL(CHART CELL): Pre-defined, scale-dependant geographic area.

CHART SYMBOL: A character, letter, line style, or similar graphic representation used on a chart to indicate some object, characteristics, etc.

CHART INFORMATION: HO-information relevant to navigation contained in nautical chart.

CHART(NAUTICAL): A chart specifically designed to meet the requirements of marine navigation, showing depths of water, nature of bottom, elevations, configuration and characteristics of coast, dangers and aids to navigation. The carriage of up-to-date charts(plus certain other nautical publications) by vessels at sea is a mandatory requirement of SOLAS regulation V 20.

CHARTLET: A small auxiliary chart giving new details on a particular area, to be added to the chart after publication. Also called block correction or chart amendment patch.

COASTAL WARNING: A navigational warning promulgated by a national co-ordinator covering a coastal or a portion thereof.

COMMITTEE ON EXCHANGE OF DIGITAL DATA (CEDD) : IHO Committee tasked with the development and coordination of a standard digital exchange format.

COMMITTEE ON ECDIS (COE) : A committee of the IHO responsible for ECDIS matters works in close relationship with the CEDD and the CSC (Chart Specifications Committee). Conducts work through several specialist working groups, including the Group of Experts dealing with specifications, and the WG on Updating ECDIS.

DATA BASE : An organized, integrated collection of data stored so as to be capable of use by relevant applications with the data being accessed by different logical paths. Theoretically it is application-independent but in reality it is rarely so.

DATA STRUCTURE: A specification of the logical organisation of the components of a data model and the manner in which relationships among components are to be explicitly defined.

DATA MODEL: A conceptual specification of the sets of components and the relationships among the components pertaining to the specific phenomena defined by the model reality. A data model is independent of specific systems or data structure.

DATA: A representation of facts, concepts or instructions in a formalised manner suitable for communication, interpretation or processing.

DATUM: vertical. A surface to which elevation and / or depths (soundings and tide heights) are referred. For elevations commonly a level (equipotential) surface, approximating to mean sea level is used, for depths in many cases low water. Also called chart datum, datum level, datum plane, reference level, reference plane.

DATUM: A set of parameters specifying the reference surface coordinate system used for geodetic control in calculation of coordinates of points on the earth. Commonly datums are defined as horizontal and vertical datums separately. For the practical use of the datum it is necessary to have one or more well monumented points with coordinates given in that datum.

DATUM: horizontal. A set of parameters specifying the reference for horizontal geodetic control, commonly the dimension and the location of a reference ellipsoid. At least five quantities are required: the semi-major axis a , the flattening f , and the coordinates ϕ , λ , h of an initial point. Absolute datums specify the centre of the reference ellipsoid to be (ideally) located at the earth's centre of mass. In modern reference systems especially those with datum information given by satellite orbits (e.g. WGS 84) additional parameters are defined, e.g. gravity models.

DIFFERENTIAL GPS(DGPS): A form of GPS in which the reliability and accuracy are enhanced by broadcasting a time-varying correction message from a GPS monitoring receiver (Differential Model) at a known position on shore. The corrections are fed automatically to the GPS receiver on board and used to compute an improved position.

DIGITIZATION(digitisation): The process of converting analog data to digital data.

DIRECTORY : Defines the contents of the transfer in terms of the included modules, specifies how to access individual modules, and specifies the relationships between modules. It also relates modules to spatial domains. It therefore describes the physical, logical and spatial organization of the transfer at the module level.

DIRECTORY OF MARINE INFORMATION : A directory containing a list of countries contributing data to the RECC, geographical area of the data coverage, scale of charts, category of navigational information, policy on data exchange etc. (Writer's definition).

DISPLAY BASE: The level of SENC information which cannot be removed from display, consisting of information which is required at all times in all geographic areas and all circumstances. It is not intended to be sufficient for safe navigation.

DISPLAY: A visual presentation of data (eg a line of alphanumeric data, a window, or the entire screen).

DX90-FORMAT: Format for the encoding or interchange of digital cartographic data developed by CEDD. DX90 is part B of the IHO Transfer Standard for Digital Hydrographic Data(S-57).

ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS) : A

navigation information system which can be accepted as complying with the up-to-date chart required by regulation V/20 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigation chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and if required display additional navigation-related information.

ELECTRONIC NAVIGATIONAL CHART DATA (ENCN): The national data for an Electronic Navigational Chart (ENC) in a format acceptable to an ENC Coordinator.

ELECTRONIC NAVIGATIONAL CHART DATA BASE (ENCDB): The master data base for production and maintenance of the ENC, compiled from national ENC data(ENCN).

ELECTRONIC CHART SYSTEM(ECS): Generic term for equipment which displays chart but which is not intended to comply with the IMO Performance Standard for ECDIS. ECS is intended for use in conjunction with a paper chart.

ELECTRONIC CHART DATA BASE (ECDB) : The master data base for Electronic Navigation Chart Data (ENCN), held in digital form by the national hydrographic authority, containing chart information and other nautical and hydrographic information.

ELECTRONIC CHART : An integrated, interactive, navigation information system, with which the user can display the hydrographic and positional information that is required to conduct the safe navigation of his vessel. It comprises hydrographic and cartographic data bases containing information useful for navigation.

ELECTRONIC NAVIGATIONAL CHART(ENC) : 1. An electronic navigational chart is a subset of the electronic chart data base held on the vessel. It contains information on features useful for navigation such as coastline, obstructions, beacons etc.

2. The data base, standardized as to content, structure and format, issued for use with ECDIS. The ENC is equivalent to the new edition of the paper charts, and may contain additional supplemental nautical information.

ENHANCED GROUP CALL (EGC): A global automatic service by INMARSAT for addressing commercial messages(FleetNet) or marine safety information(MSI)(SafetyNet) to groups or ships or all vessels in both fixed and variable geographical areas. Data transmission is based on INMARSAT Standard-C and takes place at an effective transmission rate of 600 bits/s.

EXCHANGE FORMAT: A specification for the structure and organization of data to facilitate exchange between computer system.

FILE : A collection of data for a specific task or purpose stored on a mass storage device.

FLEETNET: An INMARSAT EGC service, providing a commercial service for national and company fleet group calls, and the possibility of subscription services for news, stock exchange information, fish landing prices, etc.

GENERALISATION : The selection and or omission of less important detail for presentation of features at an appropriate scale. Its purpose is to avoid congestion on charts/maps where space is limited.

GEOGRAPHIC INFORMATION SYSTEM (GIS) : A system for storing, checking, integrating, manipulating, analyzing and displaying data which are spatially referenced to the earth. This is normally considered to involve a spatially referenced computer data base and appropriate applications software.

GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM: The communication service, co-ordinated worldwide, comprising functions which include among others, the:

- dissemination of marine safety information: broadcast of navigational and meteorological warnings, Notices to Mariners, and urgent information to shipping;
- general radio communications: those communications between ship station and shore-based communication networks which concern the management of the ship and may have an impact on its safety, and
- bridge-to-bridge communications: inter-ship VHF radiotelephone communications for the purpose of assisting the safe movement of the ship.

HARDWARE : All physical material components of a computer system as e.g. central processing unit (CPU), peripheral devices etc. May also include individual chips.

HARMONIZATION GROUP ON ECDIS (HGE) : Joint Working Group of IMO and IHO tasked to develop the performance standard for ECDIS.

INFORMATION : Intelligent resulting from the assembly, analysis or summary of data into a meaningful form.

INMARSAT : International Maritime Satellite Organisation, an international consortium which provides worldwide satellite communications links to ships at sea.

INTERNATIONAL MARITIME SATELLITE ORGANISATION: An international consortium which provides worldwide satellite communication links to ships at sea.

ISSUING AUTHORITY : The official agency which issues the ENC and ENC updates. Its identity will depend on the organisational structure adopted for ECDIS support.

INTERNATIONAL HYDROGRAPHIC BUREAU : Founded in 1921 in the Principality of Monaco, to establish a close and permanent association among the hydrographic offices of its Member States; since 1970 the headquarters of the IHO. (Hydrographic Dictionary, 1990).

INTERNATIONAL HYDROGRAPHIC ORGANISATION (IHO) : Coordinates the activities of national hydrographic offices; promotes standards and provides advice to developing countries in the fields of hydrographic surveying and production of nautical charts and publications.

INTERNATIONAL MARITIME ORGANISATION (IMO) : Formally called IMCO, the IMO is the specialized agency of the United Nations responsible for maritime safety and efficiency of navigation.

LIST OF LIGHTS : A publication tabulating navigational lights, with their locations, candle power, characteristics, etc. to assist in their identification, and details of any accompanying fog signal. A list of lights may contain other information useful to a navigator. Also called light list.

MARITIME SAFETY INFORMATION : Navigational and meteorological warnings, Notices to Mariners, meteorological forecasts, and other urgent safety messages.

MEMBER STATES : States or countries in sub-Saharan Africa that are members of the IHO and those with observer status (Writer's definition for the purpose of this report).

MINIMUM CONTENT : The minimum content of HO-data to be stored in the ENC, i.e. the data needed to produce the Standard Display plus All Other Chart Information. This will contain at least the same information relevant to safe navigation as is at present on the paper chart.

NAVAREA : A geographical sea area established for the purpose of co-ordinating the transmission of long range Radio Navigational Warnings.

NAVAREA WARNING : A navigational warning issued by the NAVAREA co-ordinator for the NAVAREA.

NAVIGATION AID : Any instrument, device, chart, method, etc., used on board intended to assist in the navigation of a craft.

NAVIGATIONAL WARNING : A broadcast message containing urgent information relevant to safe navigation.

NAVINFONET : Navigational Information Network - A US (DMA) automated service for providing Notice to Mariners and other safety information via digital link at user request.

NAVTEX : Narrow-band direct-printing telegraphy system for transmission of navigational and meteorological warnings and urgent information to ships.

NORTH-UP DISPLAY : The information is shown on the display (radar or ECDIS) always with the north direction upwards. Corresponds to the orientation of the nautical charts but differs usually from the view from the ship's bridge in the direction of the ship's heading.

NOTICES TO MARINERS : A periodical or casual notice issued by hydrographic offices, or other competent authorities, regarding changes in aids to navigation, dangers to navigation, important new soundings, and, in general, all such information as affects nautical charts, sailing directions, light lists and other nautical publications.

OWN SHIP'S SYMBOL : A non-chart symbol used in ARPA and ECDIS to show the ship's position on the chart or ARPA display.

OWN SHIP : The term which identifies the vessel upon which an ECDIS is operating.

OWN SHIP'S SAFETY CONTOUR : The contour related to the own ship selected by the ship's master out of the contours provided for in the SENC, to be used by ECDIS to distinguish on the display between the safe and the unsafe water, and for generating anti-grounding alarms.

PERFORMANCE STANDARD : Standard developed under the authority of IMO to describe the minimum performance requirements for navigational devices and other fittings required by the SOLAS Convention.

PIXEL : Contraction for "picture element". The smallest element resolvable by electronic raster devices such as scanner, display and plotter.

PRECISION : The degree of refinement of a value. Not to be confused with accuracy.

PRESENTATION : Cartographic design including drawing, use of symbols, use of colours, use of conventional practices, etc.

PRESENTATION LIBRARY : A set of mostly digital specifications, composed of symbol libraries, colour schemes, look-up tables and rules, linking every object class and attribute of the SENC to the appropriate presentation of ECDIS display. Published by IHO as Appendix 2 of its Special publication 52 (S-52).

RESOLUTION : Capability of depicting detail, represented by the smallest distance apart at which two objects can be seen as separate. Depends on the pixel size, i.e. screen dimension divided by the number of pixels.

ROUTE PLANNING : An ECDIS function in which the area is displayed which is needed to study the intended route, to select the intended track, and to mark the track, its way points and navigational notes.

ROUTE MONITORING : The operational navigational ECDIS function in which the chart information is displayed, under control of the positioning sensor input, according to the vessel's present position (either in true motion or relative motion mode).

SAFETYNET : INMARSAT Broadcast Service for MSI - A service provided through INMARSAT'S EGC system which will be used by Administrations for the promulgation of Maritime Safety Information, such as NAVAREA and storm warnings, Notice to Mariners, shore-to-shore distress alerts and routine weather forecasts to the high seas and those coastal waters not served by NAVTEX. IHO proposes to include promulgation of electronic chart corrections as well.

SAILING DIRECTIONS : Information published in book form describing coasts, waters, channels, harbour facilities, etc., for use by mariners.

SOFTWARE : All programs which can be used on a computer system. In particular the system software (i.e. the operating system) consists of all programs which are necessary for the proper functioning of the computer and for the provision of appropriate services to the user. The application software consists of all programs developed for special user applications.

SOLAS : International Convention for the Safety of Life at Sea developed by IMO. The contracting governments undertake to promulgate all laws, decrees, order and regulations and to take all other steps which may be necessary to give the present Convention full and complete effect, so as to ensure that, from the point of view of safety of life, a ship is fit for the service for which it is intended (Article Ib of SOLAS)

STANDARD DISPLAY : The SENC information that should be shown when a chart is first displayed on the ECDIS and depending upon the needs of the mariner, the level of the information it provides for route planning or route monitoring may be modified by the mariner.

SYSTEM ELECTRONIC NAVIGATIONAL CHART : The data base, transformed by ECDIS from the ENC for optimum use, and updated by appropriate means. The SENC is the data base that is actually accessed for display generation and other navigational functions. The SENC contains the equivalent to the up-to-date paper chart.

UPDATE FILE : Special file in the ECDIS reserved for the storage of updates to ENC data.

WORLD WIDE NAVIGATIONAL WARNINGS SERVICE : A coordinated global service for the promulgation by radio of information on hazards to navigation which might endanger international shipping.