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ECDIS: A EUROPEAN PERSPECTIVE

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Abstract

This article reviews the European requirements connected with the implementation of ECDIS. It is a slightly modified version of a report prepared for an action on ECDIS and maritime transport launched in February 1994 within the framework of the European COoperation in the field of Scientific and Technical research (COST 326), under the aegis of the Directorate General for Transport of the European Commission.

INTRODUCTION

The concept of an Electronic Chart Display and Information System (ECDIS) was introduced in the early 1980's in order to improve safety and efficiency of navigation as well as to provide better protection of the maritime environment.

An ECDIS consists of two main elements:

- a data base, called the Electronic Navigational Chart (ENC), containing in a digitized form all necessary geographic information,
- the equipment on board necessary for the display of the information, including real time positioning and route information from navigation sensors, with the capability of accepting updates to the ENC data.

The technical requirements for ECDIS are defined by various standards and specifications approved or being considered by international bodies such as:

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- Specifications for chart content and display aspects of ECDIS (International Hydrographic Organization [IHO], S52, 4th edition, December 1994),

- IHO transfer standard for digital hydrographic data (IHO, S57, 2nd edition, November 1993),

- Performance standards for ECDIS (International Maritime Organization [IMO], draft, Maritime Safety Committee / Circular 637, 27 May 1994),

- ECDIS - Operational and performance requirements - Methods of testing and required results (International Electrotechnical Commission [IEC] / Technical Committee 80 / Working Group 7, draft, 1994).

These documents define minimum requirements tailored for standard navigational applications. Extra requirements related to specific regional conditions or to the wider range of all potential applications may be necessary.

In February 1995, the G7 countries put the electronic chart into the broader framework of creating a Maritime Information Society (MARIS). This initiative addresses issues such as:

- Maritime safety and protection of the maritime environment,

- Sharing knowledge to use and protect marine resources.

The objective of this initiative is the implementation of a global information system which builds on the existing systems by promoting interoperability and the development of international cooperation to create new services on a global basis.

Two sub-projects within MARIS have a direct bearing on ECDIS:

- SAFEMAR (MARitime SAFEty): making chart data available in electronic form, and using the electronic highway to disseminate electronic charts, updates and real-time weather, water level and logistic data to vessels to improve marine navigation safety and efficiency, and developing the ship reporting system for vessels carrying dangerous or polluting goods in order to improve environment protection.

- MARSOURCE(MARine reSOURCEs): developing a world-wide fisheries and oceans information network linking existing databases containing information on oceanography, fisheries and scientific research to support global decision making.

This article reviews the various aspects of ECDIS in order to identify specific European requirements.

GENERAL CONDITIONS IN EUROPEAN WATERS

The European maritime area is characterized by a specific combination of various conditions, although many of the individual European features can be found elsewhere in the world.

Environment

The bathymetry and coastlines are complex in some areas such as the coast of Norway, in the Baltic Sea, around the British Isles and in the Aegean Sea. Most traffic lanes include narrow and shallow channels such as the Sound in the Baltic Sea, Dover Strait between the English Channel and the North Sea, the Strait of Gibraltar between the Atlantic Ocean and the Mediterranean Sea and the Strait of Messina between the Tirreno and Ionian Seas. Banks and the channels between them, in certain areas such as Dover Strait and the Southern North Sea, may be unstable. Besides natural hazards, which do not occur only in Europe, the European continental shelf is characterized by numerous underwater obstructions whose density is rarely met elsewhere. Due to two world wars, adverse weather conditions, poor navigation and seamanship, thousands of wrecks litter the European shelf. The multiplication of submarine cables laid on the seabed for communication purposes and the development of offshore oil and gas exploitation are the origins of more bottom obstructions. These obstructions present a particular danger to fishing vessels as well as to submarines. The most sensitive zones are the English Channel, the North Sea and certain areas of the Baltic Sea.

Strong tides and tidal currents are encountered in various areas. Tidal ranges greater than 14 meters are observed in the English Channel and in the Bristol Channel. Tidal currents exceed 5 knots in certain areas of the English Channel. Meteorological conditions may induce strong variations in comparison with predicted values. Storm surges have had devastating effects on the low shorelines of England and the Netherlands.

In winter, the formation of sea ice impedes navigation in the Baltic Sea and, to a lesser extent, along the northern coast of Norway.

Maritime traffic

The traffic situation along European maritime routes is probably unique in its intensity and variability. Congested areas must accommodate deep draught vessels, crossing high speed ferries and bad meteorological conditions. For instance about 350 ships sail into Dover Strait every day while 150 other units cross between England and the continent.

As everywhere else in the world, the main European ports are often located in estuaries whose access may be difficult. In autumn and winter, North

European ports also suffer from reduced visibility: for instance, in Hamburg (Germany), visibility is less than one kilometre six to eight days per month in December and January. The busiest port in the world is Rotterdam (Netherlands) with a traffic of almost 300 million tons each year. Antwerp (Belgium) and Marseille (France) handle more than 80 million tons annually. More than 30,000 ships enter Rotterdam each year while Antwerp and Hamburg each receive more than 10,000 ships each year.

Europe is highly dependent on maritime transport. More than 70 % of the total tonnage traded between the European Union and other countries is handled by sea. Maritime traffic accounts for around 30 % of the tonnage traded between European countries. Three out of four ship movements carry dangerous goods.

The development of intermodality between the different modes of transport may be regarded as a promising way of improving European transport systems. In that respect, improved interoperability between maritime transport, especially short sea shipping, and inland waterway transport must be ensured.

Services

Various positioning systems are available in European waters. Shore-based radiopositioning systems include local Syledis or Decca chains and regional Loran C chains. A new North West European Loran C System, which should be operational in 1996, will provide an accuracy better than 100 meters from the northern coast of Spain to Iceland and the northern coast of Norway. The world-wide Global Positioning System (GPS) can also be used throughout Europe, in the standard or differential mode. Many reference stations have been installed in the Scandinavian countries, in the United Kingdom and in France and provide a permanent accuracy better than 10 meters. For lack of a general agreement between manufacturers, these networks are not yet fully compatible. Coverage in the Mediterranean is still far from complete. Moreover, there is a need for a secondary positioning system to be integrated with ECDIS as called for by IMO performance standards for ECDIS.

Traffic separation schemes have been implemented in most narrow passages. Shore-based surveillance centres supervise the traffic using radars and radio links.

A comprehensive buoyage system is maintained throughout Europe. Due to bad weather or collisions, buoys are frequently displaced.

In spite of more than 250 years of surveying activities, the status of hydrographic surveys in European waters is not fully satisfactory. Large areas such as the centre of the North Sea or the western part of the Channel have been surveyed by lead-line only or by widely spaced lines of sounding. Besides, even less antique information may not meet the accuracy requirements of navigators using differential GPS (DGPS) positioning. The widespread use of multibeam sounders and DGPS positioning systems on board survey ships will allow dramatic improvements in the future.

There are in Europe as many charting authorities as there are maritime countries. Each national Hydrographic Office has the primary responsibility for a relatively small area but must meet the wider charting requirements of its national constituency which may encompass world-wide shipping lanes and ports and military needs. The United Kingdom Hydrographic Office plays a special part as the only European world-wide charting agency. Within the North Atlantic Treaty Organization (NATO), the US Defense Mapping Agency (DMA) has also a strong lead in providing world-wide digital geographic products. Many port authorities have their own hydrographic department, e. g. Hamburg, London, Bordeaux, etc.

Some European cooperation has already developed bilaterally or multi-laterally within the four regional hydrographic commissions created under the general guidance of the International Hydrographic Organization (IHO). Yet this divided situation entails some duplication of efforts in training, research and development activities as well as in the production of charts and nautical documents. Although progress has been made in product standardisation, the military status of many Hydrographic Offices as well as the language problem still constitute real barriers to any consolidation at the European level.

The European Hydrographic Offices, like all Hydrographic Offices, have been rather slow in developing digital products to meet ECDIS requirements. Limited data sets have been made available only recently, mainly for test purposes. This situation has led to the development of a private sector which provides non official products obtained through digitizing paper charts, with or without the agreement of chart publishers.

APPLICATIONS

Navigational applications

Merchant shipping

Safe navigation has long been relying on the use of paper charts and nautical books kept up-to-date through Notices to Mariners. On modern ship bridges fitted with the latest electronic devices, with ARPA and GPS/DGPS, but manned by fewer and fewer watch officers, the paper products not only look quite old-fashioned but turn out to be too unwieldy for today's mariners. This is proven by the appalling increase in the number of deficiencies identified by routine inspections of charts and nautical publications held by the ships, as noted in the European annual report of Port State Control. From 1992 to 1994, this number rose by 230 % (charts: from 589 to 1,352 cases; nautical publications: from 966 to 2,207 cases), rendering this type of deficiency the most significant in the " navigation " group by far.

It may not be a genuinely European problem, but it certainly is a very serious one in confined and congested European waters. It may be concluded that future official electronic navigational products must cover the entire range of information, including the contents of nautical publications, and that a comprehensive ECDIS coverage must be established in Europe as soon as possible so that nautical

and hydrographic information provided by Hydrographic Offices can really fulfil the requirements for the safety of navigation.

On top of IMO minimum requirements, the European context also call for additional services associated with standard ECDIS.

To allow precise navigation in confined waters, ECDIS should be enhanced through provisions of high resolution digital terrain models (DTM's) as part of the data base. This must be supported by high accuracy positioning such as DGPS. Complete surveys with multibeam sounder will be necessary to derive accurate DTM's. Unstable areas will have to be resurveyed frequently to maintain a proper level of accuracy. The production of very large scale datasets will also be necessary in ports where ECDIS will be very useful to control docking manoeuvres even during periods of limited visibility. In many cases, these types of data do not yet exist at the source level.

In areas of strong tidal variation with little underkeel clearance, the display of real time depth would be preferable to the display of soundings referred to chart datum.

Provision of up-to-date and predicted current data would facilitate navigation in areas of strong tidal currents and allow route optimization and manoeuvring simulation. Numerical models driven by meteorological wind forecasts could be used to provide the necessary information.

In areas subject to ice conditions, ice information derived from satellite remote sensing data could be handled as another optional superimposition on standard ECDIS data.

Data requirements of European mariners are not limited to European waters. The main world-wide shipping lanes to and from Europe are also concerned. On a global scale, providing data to improve marine navigation safety and efficiency, including real-time data, is also an objective of the G7 SAFEMAR sub-project.

The growing requirements to ensure interoperability between inland waterway navigation and maritime navigation should also be considered as the importance of inland waterways are going to increase within Europe. Ways to harmonize inland waterway information systems and maritime ECDIS are yet to be studied.

Fishermen

One of the major benefits of ECDIS could be to make fishing a safer activity. For that purpose, the system must be able to handle a specific seabed information layer, including the fishermen's own "private" data. A precise positioning system for fishing gears may be needed to get full advantage of ECDIS in fishing activities.

Although much of the geographic data that may be relevant are already handled by national Hydrographic Offices, other information on sea bottom type and

obstructions or discarded installations should be collected from other sources - such as the fishing industry, oceanographic institutions, oil and cable companies - and harmonized with ENC data.

Integration of oceanographic, meteorological and biological activity information may also be useful in a fishing vessel ECDIS. The temporal nature of these data bases will add a new degree of complexity which should be carefully assessed.

A pilot study on this subject, called ESIS (European Seabed Information System) has been proposed to the European Commission by a consortium of four organizations (Sea Fish Industry Authority and University of Wales, UK; IFREMER, France; Rijkswaterstaat, Netherlands). Proper coordination with the implementation of ECDIS is necessary to avoid any duplication of efforts in data management.

Data requirements of European fishermen include fishing areas outside European jurisdiction, for instance in the North Western Atlantic, off the western coast of Africa or in the Indian Ocean.

Navy

Although one of the primary objectives for the NATO standardisation policy is to promote the adoption of civil international standards to the greatest extent feasible, special requirements must be met by warship ECDIS (WECDIS). These systems should replace paper charts for both navigation and warfare, including operations across the land-sea interface, and therefore should be able to handle standard ENC as well as non-navigation data such as:

topographic data,
detailed hydrographic data,
aeronautical data,
oceanographic data,
meteorological data,
real time tactical information
intelligence
electronic warfare information

These data sets will have to integrate very closely with ENC data sets. Such data integration will involve various problems such as features incoherencies or datums differences which require at least a degree of harmonization of specifications and standards between the military and civil communities. An IHO/NATO harmonization group was set up in 1994 to discuss ways of achieving harmonization of NATO's and IHO's data exchange standards.

Vector data is probably more suitable for interoperability than raster data because of its flexibility in display and analysis. However due to the high cost of vector data production, there will be for some years a requirement to integrate vector and raster data.

Submarine navigation requires the provision of up-to-date and complete information on underwater obstructions for safety purposes as well as military purposes.

Overlap between military and fishermen requirements for seabed information must be taken into account, military classification constraints permitting.

The numerous possibilities for future European military operations under national, Western European Union (WEU), NATO or United Nations authority call for almost world-wide data coverage.

Pleasure boats

With more than 5 million units in Europe, pleasure boats make up a significant part of European paper charts users. To meet their special needs, national Hydrographic Offices and private publishers have already developed specific editions of charts and documents. The flexibility of electronic products should allow better adjustment to recreational requirements.

The integration of sailing directions on top of the ENC data base could facilitate visual navigation. Another specific layer could include meteorological information, information on port services and accommodation as well as tourist information.

Wide recreational use of ECDIS-like systems will require applications tailored for low-cost, compact and energy-saving devices.

Data requirements include large scale coverage of coastal European waters. European boaters may also be interested in ENC data outside Europe, for instance in the West Indies. Most existing large scale data is still in analogue form.

On-shore applications

ENC data will also be useful for on-shore applications. Potential users include:

port and marine authorities,
vessel traffic services (VTS),
maritime rescue coordination centres (MRCC),
pollution control centres,
authorities responsible for controlling and monitoring the exploitation of seabed and marine resources
inland waterway information systems

ENC data will have to be integrated with other sources of geographical information such as radars or meteorological data.

ENC data could provide a common geographic reference frame for the interconnection of the numerous European MRCC and VTS through the European

Water Traffic Information System (EWTIS) and the Traffic Data Management System (TDMS), as envisaged by the SAFEMAR sub-project of the MARIS initiative.

Coastal zone management also requires comprehensive large scale data sets of the coastal zone on both sides of the coastline. Applications range from coastal engineering to administrative tasks and preventive measures against pollution. Much has been said and written about coastal management but most advances have been made at the local level. A European approach to the integration of ENC data and land-based GIS might be useful. Additional marine information on currents, tides, water quality and biological parameters would enhance such integrated data bases. Much data on the seaward side of the coastline still needs to be collected in order to produce workable coastal management systems. There is also a need to identify and digitize much of the existing data.

Across Europe, a number of local or national government bodies, research institutes and private companies are currently involved in projects dealing with coastal and marine information systems, some of which are sponsored by the European Union. Some coordination is needed to avoid unnecessary duplication of time and money-consuming efforts.

Under the MARIS initiative, the sub-project MARSOURCE aims at establishing a link of existing databases into a world-wide fisheries and oceans information network. Such network would enable politicians, scientists and managers from around the world to share information and expertise and thus have better tools for global decision-making regarding international fisheries and oceans conservation and management. Taking into account at also ECDIS draws on marine databases, e. g. bathymetry data, and that there is a need of providing operational forecast data of oceanographic and meteorological parameters, interlinking marine navigation databases with environmental databases offers a broad range of additional applications.

DATA MANAGEMENT AND COMMUNICATIONS

Production

The first barrier before ECDIS and related systems can become fully operational lies in the production of ENC data. A general framework for the production and distribution of ENC data on a world-wide basis has been adopted by the Member States of IHO as the World-wide Electronic Navigational chart Database (WEND) scheme. The general principles of this scheme are as follows:

- each Member State is responsible for the production, validation and updating of its national data set;

- national data sets are integrated into regional data sets under the responsibility of a Regional Electronic Navigational chart coordinating Centre (RENC);

- responsibilities for the production of data outside areas under national jurisdiction remain to be established.

Another committee under IHO, the Committee On Electronic data (COE), is developing technical specifications, including an ENC product specification which should be adopted early in 1996.

The first regional centre has been established by Norway for Northern Europe (North Sea, Baltic Sea, Channel). Major European Hydrographic Offices are implementing GIS projects to be able to produce ENC data sets for their national waters by 1996-1997. Small to medium scale coverage of the North Sea, Baltic Sea and Channel should be available in that time frame. Production of data for the Central Eastern Atlantic and the Mediterranean will probably be limited for some years to France, Spain, Portugal and Italy. Plans for the production of data in other national areas have yet to be determined. Data production in the Mediterranean will also be hindered by the absence of any agreement on maritime boundaries. The production of good quality data for important areas outside European jurisdiction such as the tanker route between Europe and the Persian Gulf will require completion of new surveys.

Possible options include local production with technical assistance of more advanced HO's, production by leading HO's or temporary use of non equivalent Electronic Chart System (ECS), or hybrid systems, using officially produced raster navigational charts such as those produced for the Admiralty Raster Chart Service (ARCS) by the UK Hydrographic Office.

The US DMA intends to provide by the end of 1997 a world-wide data set under its Digital Nautical Chart (DNC) program. The position of this unilateral program under the WEND scheme and NATO geographic requirements has not yet been settled.

Fusion

Under the WEND scheme, regional coordinating centres (RENC) are responsible for the integration of national data sets. The North Europe RENC should be able to meet the corresponding requirements sometimes in 1995 or early 1996.

Communications

Communications requirements associated with the implementation of ECDIS include:

data exchange between Hydrographic Offices and regional centres,
dissemination of data to international shipping,
dissemination of data to national users,
dissemination of data to shore-based systems,
communication between shore-based systems and ships (e.g. ARPA targets and navigational warnings from VTS to ship's ECDIS).

Updating

General updating procedures have been defined by IHO as a part of its specifications for ECDIS (publication S-52, appendix 1). Recent sea trials conducted in conjunction with the Baltic and North Sea ECDIS Testbed (BANET), initiated and coordinated by Germany, have proven the feasibility and efficiency of automatically updating the ENC at sea, using modern telecommunications, and have led to further improvements of the specified updating procedures.

Integration of complementary information

The need to integrate meteorological, oceanographic and biological data bases has been already mentioned. Ways and means of achieving such integration remain to be assessed.

EQUIPMENT

The European market covers the full range of equipment from the lower end tailored to meet recreational requirements to highly sophisticated military systems. The development of ECDIS equipment in Europe is still in embryo for lack of definite specifications. Some experience has been acquired by developing non equivalent Electronic Chart Systems (ECS) and in various ECDIS-like testbeds.

CONCLUSION

This review has identified specific European requirements related with the implementation of ECDIS. They involve the following aspects:

- support and consolidation of individual hydrographic offices efforts, including production of ENC data in areas outside national jurisdiction,
- coordination of various European projects dealing with maritime information systems, as well as with the G7 MARIS initiative,
- harmonization of military and civil specifications and data requirements, in order to minimize duplication of efforts,
- industrial development of ECDIS equipment for the whole range of potential users,
- integration of complementary data, including time varying information,
- interoperability between maritime and inland waterway information systems.

Related issues which must also be addressed at the European level concern:

- relations with the United States,
- implementation of Europe-wide accurate primary and secondary positioning systems,
- identification of survey requirements within and outside Europe and adoption of an implementation strategy.