

On-shore SENC Conversion

*Improving the Reliability, Efficiency and Safety of
ECDIS converting onshore the ENC data into a
SENC.*

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ABSTRACT

For some time the delicate step of converting on-board the ENC's has been perceived as a weak link in the overall ECDIS concept.

In fact ENC's are very complex, have a poor consistency originating from a variety of official sources and are cumbersome to handle.

To overcome this drawbacks ECDIS manufacturers, users and data distributors have identified the simple solution of converting S-57 ENC's into a SENC format, BEFORE they go out to ships.

This paper describes a practical implementation of this approach.

1.1.Introduction

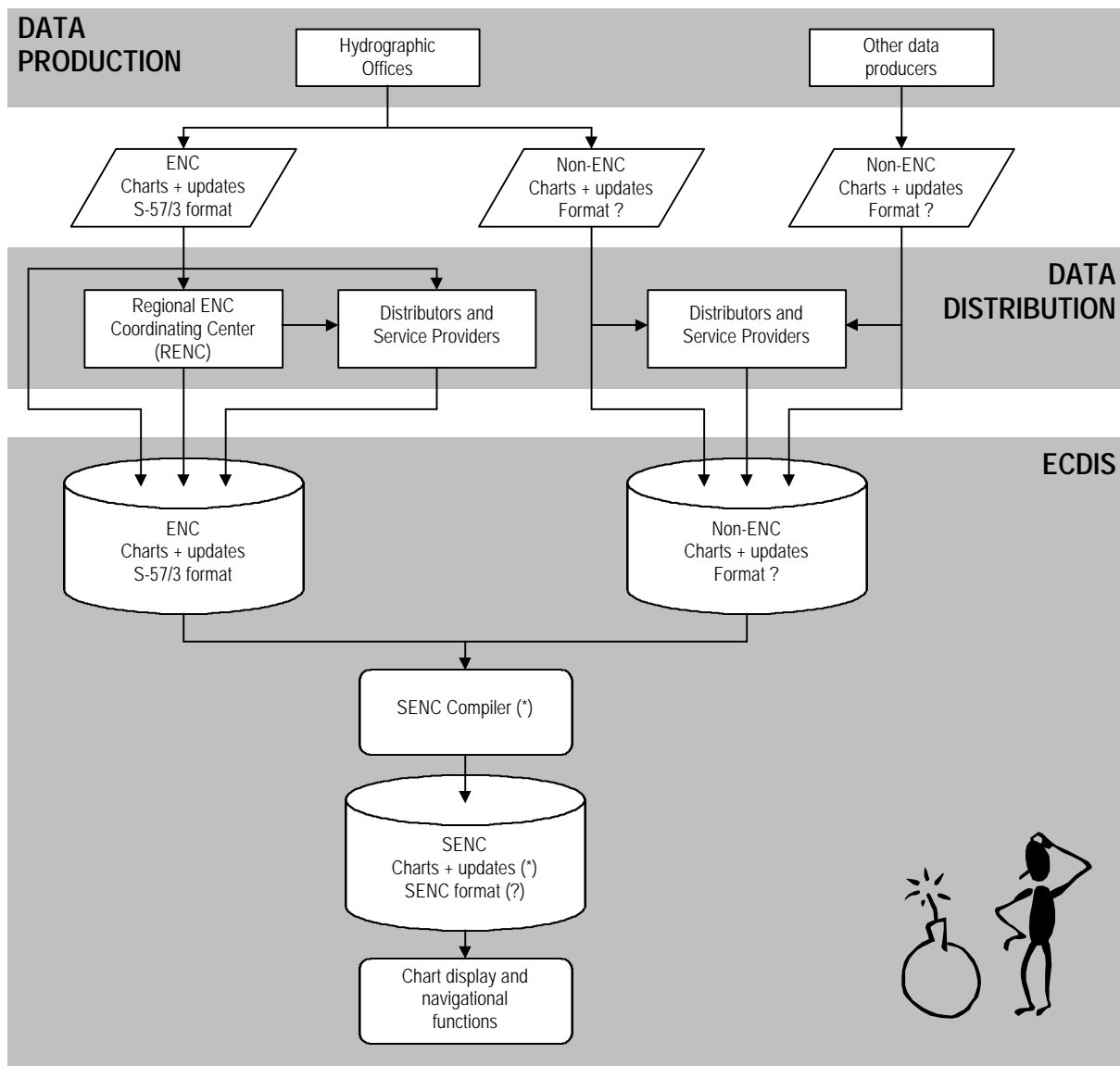
The ECDIS Performance Standard recognizes the need for a system-specific data format called SENC (System ENC) to optimize the performance of the ECDIS software. For instance, CM93 is a proprietary SENC adopted by many manufacturers and supported by C-MAP. Therefore, to be used, an ENC must be always converted into a SENC. There is a certain ambiguity in the Performance Standard with respect to the requirement of performing this conversion on board of the ship. C-MAP, most manufacturers and some classification societies (e.g. DKV) believe that a conversion implemented onshore will not only be compatible with the standard, but will offer significant advantages.

For instance:

- 1- the SENC is more compact and will therefore simplify the problem, and reduce the cost, of transmitting updates;
- 2- the automatic conversion of S57 ENC data into a SENC is a process that, occasionally, breaks down due to non-standard S57 interpretation or plain errors. These problems can be easily fixed onshore, but not on the ship;
- 3- ENCs originating from different HOs or RENCs can create problems of harmonization (overlapping areas, etc.). The SENC sent to the ship will have all these problems resolved before being transferred and can be supplemented with non-equivalent data in an optimal way.

1.2. The Traditional Approach

The following diagram shows the flow of electronic chart data to ECDIS, according to the most traditional approach.



(*) Distinction is maintained between official ENC and other data.

1.2.1. What the Regulations Say

ENC (electronic charts and updates) in S-57/3 format are produced and issued by **national Hydrographic Offices**, then distributed to vessels either directly, or through a **Regional ENC Coordinating Centre (RENC)**, that also performs quality checking and integration, or through other distributors and service providers.

On the ship, S-57/3 data is loaded into the ECDIS in a dedicated storage area, called the **ENC database**; this shall only include ENC issued by Hydrographic Offices.

Since the S-57/3 format is not suitable for data processing, the ECDIS shall convert the ENC into a different format (usually binary and more compact than S-57/3), called the **SENC (System ENC) format**. A special module of the ECDIS software, the **SENC Compiler**, performs the conversion from ENC to SENC. The resulting data is loaded into a separate storage area, the **SENC Database**, from where it is accessed by the chart display and navigational functions of ECDIS. The ECDIS manufacturer may choose whatever format and database structure for the SENC, provided that data is not downgraded in accuracy and/or contents during the conversion from ENC to SENC.

1.2.2. The Dark Side: What the Regulations Do Not Say

The above scheme, while apparently very simple and convenient, has a major drawback in the conversion from ENC to SENC performed internally to the ECDIS. The problem is that the SENC is generated by the ECDIS, and **never tested** before being used by the ECDIS itself.

It may be objected that the SENC Compiler, as part of a type-approved ECDIS, has undergone a severe testing procedure, and is therefore assumed to be robust, reliable and exact; as regards the ENC, this is presumably error-free, inasmuch as subject to strict quality checking by the producing Hydrographic Office, and possibly by the RENC. Nevertheless, as any conscientious software engineer will be ready to testify, there is always a certain degree of uncertainty in format conversion, that could result in partial data loading, unexpected behaviour of the ECDIS, or (even if this is quite an extreme possibility) a system crash. Also, the conversion of a large amount of data may be a lengthy affair, and could absorb a large part of the ECDIS resources, maybe right in the moment in which the system is performing a critical computation or analysis.

The lack of official ENC makes things just worse. Even if a number of Hydrographic Offices have started ambitious programs of ENC production, very few official electronic charts in S-57/3 format are available today. The result is that ECDIS users have to supplement ENC data with **non-ENC electronic charts**, such as:

- commercial databases of electronic charts, produced by organizations other than Hydrographic Offices ('Other data producers' in the diagram);

- electronic charts produced by Hydrographic Offices, not compliant with S-57/3 (e.g. vector charts in formats other than S-57/3, raster charts, etc.).

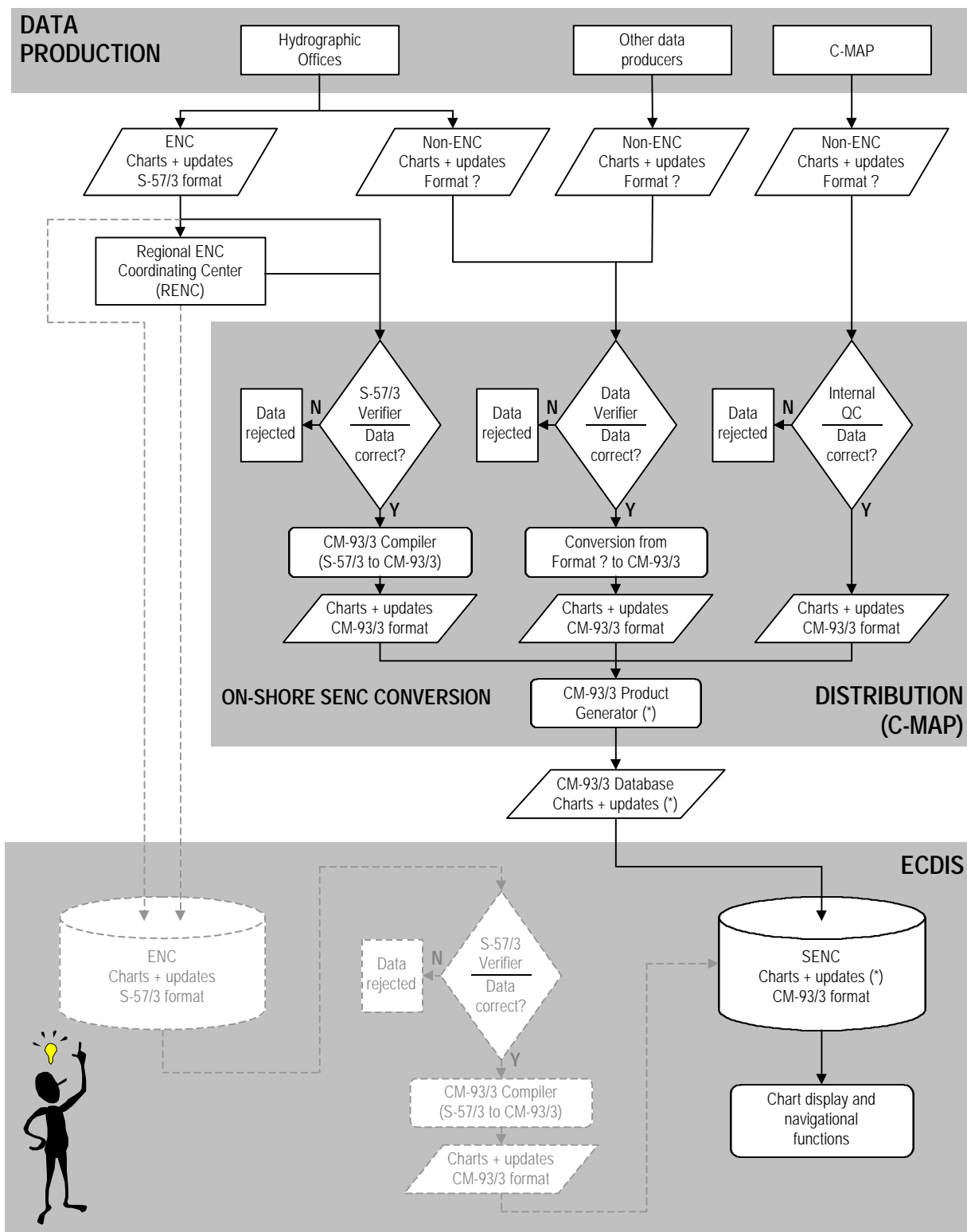
This is the concept of the so-called **dual-fuel ECDIS**: a system fed with both ENC and non-ENC electronic charts.

Since the ECDIS operates in non-equivalent mode when using non-ENC charts, S-52 and the IMO PS require that these are not mixed with the ENC. Therefore, they must be loaded in the ECDIS into a separate storage area ('Non-ENC' in the diagram), and must remain clearly distinguishable from official charts even after compilation in the SENC.

It must be stressed that quality of non-ENC charts may vary to a large extent, and their format may be very different from S-57/3. This adds further complication (and potential problems) to the task of the SENC Compiler, that has to blend into a single database electronic charts with different features.

1.3. The Innovative Approach: CM-93/3

In order to overcome the shortcomings of traditional design of ECDIS, C-MAP has developed a completely new technology, based upon the **CM-93 Edition 3.0 format** (hereinafter **CM-93/3**).



(*) Distinction is maintained between official ENC and other data.

CM-93/3, that is a binary implementation of S-57/3, has been developed by C-MAP as a data structure for the SENC database, and supports all features of S-57/3, including application of updates. In C-MAP's approach to ECDIS, CM-93/3 is used as exchange and processing format for all electronic charts intended to be used by the ECDIS, regardless of their origin. In particular:

- ENC in S-57/3 format, produced and issued by national Hydrographic Offices and distributed directly or through a RENC, are verified by a specialized software (the S-57/3 Verifier), to ensure that they are fully compliant with the ENC Product Specification (Appendix B.1 of S-57/3). If the result of verification is positive, data is converted to CM-93/3 by the CM-93/3 Compiler, otherwise appropriate actions are initiated to correct the errors contained in the data (see section **Error! Reference source not found.**). The S-57/3 Verifier and the CM-93/3 Compiler are software programs produced and maintained by C-MAP, and both of them (as well as the CM-93/3 format itself) are in the process of being type-approved as elements of ECDIS by Det Norske Veritas.
- Non-ENC electronic vector charts produced by Hydrographic Offices or other data producers are checked by dedicated software tools, to ensure that they do not contain semantic or syntactic violations of their own data structure. If the result of verification is positive, data is converted to CM-93/3, otherwise appropriate actions are initiated to correct the errors contained in the data (see section **Error! Reference source not found.**).
- Non-ENC electronic vector charts produced by C-MAP are directly issued in CM-93/3 format, and undergo standard quality checking according to the Company's internal procedure.

As final stage of this procedure, all electronic charts are compiled by the **CM-93/3 Product Generator** into the **CM-93/3 Database**, that represents the SENC for the ECDIS on board ships. Of course, even after compilation in the CM-93/3 Database, ENC charts and non-ENC charts remain clearly distinguishable from each other.

The CM-93/3 Database is distributed to vessels, where it can be loaded into the ECDIS and directly used for data processing and display, without the need for any further conversion. In order to maintain full compatibility with all regulations, the ECDIS shall still include a storage area for the ENC, as well as a SENC compiler (that consists of the same modules—S-57/3 Verifier and CM-93/3 Compiler—used by C-MAP); the possibility of using of such features, however, is more theoretical than real, since *all* ENC charts are incorporated by C-MAP into the CM-93/3 Database, and there is no need for the ECDIS user to download them in S-57/3 format from the producing Hydrographic Office or from a RENC. The advantages of this approach are obvious. All format conversions, as well as the difficult task of harmonizing and merging

data from different sources, are performed at C-MAP facilities, under strictly controlled conditions, and not by the ECDIS installed on board. All data delivered to ships is double checked in advance, in the format in which it will be actually used by the ECDIS, to ensure that it is fully functional and does not contain 'unwanted surprises'. Any error affecting the source electronic charts is detected (and, if possible, corrected) by C-MAP, instead of being just passed off to the user.

As regards the theoretical issue of whether the original ENC in S-57/3 format should be physically present in the ECDIS or not, there are a number of considerations that could mitigate such requirement, or lead to a different interpretation of it:

- The only purpose for the ENC to exist on board is generating the SENC. In fact, whatever operation performed by the ECDIS on electronic chart data pertains to the SENC, not the ENC. Therefore, existence of the ENC in the ECDIS is purposeless, if the conversion to SENC has been already performed under controlled conditions, by a SENC compiler that is part of a type-approved ECDIS.
- S-52 and the IMO PS require that data is not downgraded in accuracy and/or contents during the conversion from ENC to SENC, meaning that ENC and SENC are logically equivalent to each other. At this point, any ENC stored in the ECDIS would represent a mere duplication of the corresponding SENC.
- Based on the above consideration, the theoretical requirement of having the ENC physically present in the ECDIS could be fulfilled by the capability of the SENC compiler to perform a back conversion (i.e. from SENC to ENC).

Appendix 1

2. A Few Basic Concepts

2.1. What Is An ECDIS?

ECDIS is an acronym for *Electronic Chart Display and Information System*. At its simplest, an ECDIS consists of a **database of electronic charts**, together with the **hardware** and **software** needed to display simultaneously the charts and the ship's own position (obtained from a GPS or another positioning sensor), and to perform navigational tasks such as route planning, route monitoring, measurement of distances on the chart, etc. One of the most important features of ECDIS, that makes it a unique aid to navigation, is the capability of generating **alarms** (anti-grounding, off route, etc.), based on input from sensors and analysis of chart information.

To be defined an ECDIS however, an electronic charting system (ECS) must comply with a number of international standards and regulations, amongst which the most important are those issued by the International Hydrographic Organization (IHO) and the International Maritime Organization (IMO):

- IHO Special Publication S-57, ***IHO Transfer Standard for Digital Hydrographic Data***, Edition 3.0, November 1996 (hereinafter called S-57/3). It describes the standard (i.e. the data model and format) to be used for exchange of Electronic Navigational Charts (ENC) between Hydrographic Offices, ECDIS manufacturers, mariners, and other data users.
- IHO Special Publication S-52, ***Specification for Chart Content and Display Aspects of ECDIS***, 5th Edition, December 1996 (hereinafter called S-52). It provides specifications and guidance regarding the issuing of ENC, their updating, and their display in ECDIS (including details about colors and symbols to be used for on-screen presentation).
- IMO Resolution A/817, ***IMO Performance Standards for ECDIS***, December 1995 (hereinafter called IMO PS). It describes the minimum performance standards for ECDIS, with reference to hardware, software, ENC and updates, user interface, integration with positioning sensors, radar and other devices, etc.).

In essence, S-57/3 defines the format of the ENC to be used in the ECDIS, while S-52 and the IMO PS describe the operational and performance requirements of the ECDIS itself.

2.2. Type Approval Of ECDIS

It is the responsibility of Classification Societies (such as Det Norske Veritas, Registro Italiano Navale, etc.) to test electronic charting systems that claim to be ECDIS, and assess whether they are compliant with all relevant standards. The following publication, issued by the International Electrotechnical Commission (IEC), provides guidelines for testing:

- IEC International Standard 61174, ***Maritime navigation and radiocommunication equipment systems—Electronic chart display and information system (ECDIS)—Operational and performance requirements, methods of testing and required test results***, 1998 (hereinafter called IEC 61174).

Systems that comply with all requirements get a *Type Approval certificate* from the Classification Society, and can be legitimately called ECDIS.

2.3. Equivalency With Paper Charts

The concept of an electronic chart equivalent to a paper chart is misleading and therefore poorly understood. An ECDIS, in fact, is so different from a paper chart that talking of equivalence in strict terms makes no sense. This misnomer originated from the necessity of legitimating a new way of navigating within the framework of the existing IMO rules. As, at the time, the only IMO recognized way of navigating was with a paper chart, any alternative system, to be legal, had to be “equivalent” to a paper chart. With this legal justification it has been possible to write an IMO compatible specification for these electronic charting systems: the ECDIS Performance Standard. This standard defines the minimum requirements that an electronic chart system must fulfill to be used as a primary means of navigation (be equivalent). Nevertheless, it must be understood that an ECDIS is a primary means of navigation that differs substantially in its use from a paper chart (similarly to the Radar). For this reason not any paper chart can be an adequate ENC source. Only the originating organization knows if the survey and compilation are accurate enough for electronic navigation, whose principles are very dissimilar from paper chart navigation. Raster charts, irrespective of the survey quality, are not acceptable because they cannot support the functionality required by this new primary means of navigation.

2.4. Legal Equivalency With Paper Charts

In order for an ECDIS to be the legal equivalent of paper charts, the following conditions must be true:

- The ECDIS must be type-approved.
- The system must be complete with a type-approved back-up system, that must enable instant and safe take-over of navigation and continuation of the voyage if an ECDIS malfunction occurs (the back-up system may range from a radar with additional navigational function, to be used together with paper charts, to a second, fully compliant ECDIS).
- The system must display official ENC, issued by a national Hydrographic Office.
- The ENC must be up to date.

If the system complies with all above requirements, it is considered equivalent to the navigational charts required by the SOLAS (Safety Of Life At Sea) Convention, meaning that paper charts do not have to be carried on board. However, as soon as the system fails to match one of the requirements, the legal equivalency decays. In particular, a type-approved ECDIS displaying data other than official ENC (such as vector chart supplied by a data producer other than an Hydrographic Office, or raster charts issued by an Hydrographic Office) is *not* equivalent to paper charts; in this case, the mariner should not rely on the ECDIS as the only source of navigational information, and updated paper charts must be available on board.

Appendix 2

3. What is New in CM-93/3 Technology

3.1. CM-93/2 vs CM-93/3

Compared to CM-93/2 (the Electronic Chart Database for the professional shipping market, introduced by C-MAP in 1993), the CM-93/3 Technology has the following advantages and new features:

- **Full compatibility with all international standards and regulations on ECDIS** (specifically IHO S-57 Edition 3.0). Although CM-93/2 was developed based on IHO S-57 Version 2.0, a complete compliance with the standard could not be achieved, mainly because of the lack (at that time) of clear definitions and interpretation rules on ECDIS. On the contrary, CM-93/3 is fully compliant with S-57/3, both formally and in terms of actual features/performances (for example, the capability of supporting the S-57/3 updating mechanism), meaning that it can be adopted as SENC format in any type-approved ECDIS.
- **Further optimization for data compactness and performance.** CM-93/3 introduces a new advanced encoding scheme and data structure that greatly enhances the performance of the ECDIS engine.
- **Complete support of ECS / ECDIS manufacturers and end users.** With CM-93/2, C-MAP already introduced the concept of OEM support, developing an extensive library of software programs to optimize data access and chart presentation. The CM-93/3 Technology includes a full range of services and tools not only for ECS and ECDIS manufacturers, but also for end users (e.g. remote ordering/licensing procedure, updating service, etc.).
- **Greater flexibility.** Users of the CM-93/3 Technology are granted the highest level of flexibility in data selection, ordering and maintenance (for

example, users are allowed to create their own chart collection, that may range from a single chart to the whole database, without any limitation). Also, various levels of service have been implemented, in order to satisfy the requirements of any type of customer or vessel (from the super-tanker with lots of communication facilities, to the fishing boat without any telephone or INMARSAT connection).