JAPAN P&I CLUB Vol.39 April 2017
P&I Loss Prevention Bulletin
The Japan Ship Owners Mutual Protection & Indemnity Association Loss Prevention and Ship Inspection Department

Electronic Chart Display and Information System

ECDIS

INDEX

Chapter 4　ECDIS Familiarisation Training

Chapter 5　Handling of Electronic Charts from the Viewpoint of the Master and Officers

Conclusion

Attachments and Reference Material

CODES TABLE

Abbreviation of Treaty/Agreement etc.	
COLREGS	International Regulations for Preventing Collisions at Sea, 1972
ISM Code	International Managemant Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management Code)
S-66	Facts about Electronic Charts and Carriage Requirements
SOLAS	International Convention for the Safety of Life at Sea, 1974
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978

Abbreviation of Organization etc.	
IHO	International Hydrographic Organization
IMO	International Maritime Organization
MOU	Memorandum Of Understanding on Port State Control
NHO	National Hydrographic Office
PSC	Port State Control
UKHO	United Kingdom Hydrographic Office

Abbreviation of Equipment and others	
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aids
BTM	Bridge Team Management
CRM	Cockpit Resource Management
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
ENC	Electronic Navigational Chart Degital Data Base of All information (Point, Line and Area) on the display
GNSS	Global Navigation Satellite System Generic Name of Satellite System(GPS, GLONASS, Galireo and etc.)
GPS	Global Positioning System
Japan ENC	Japan Electronic Navigational Chart
RCDS	Raster Chart Display System
RENC	Regional ENC Co-ordination Center
RNC	Raster Navigational Chart
SA Certificate	Scheme Administrator Certificate：SA Certificate
SENC	System Electronic Navigational Chart
WGS-84	World Geodetic System-84

Introduction

The Hydrographic Department of the Japan Coast Guard (now known as the Hydrographic and Oceanographic Department, Japan Coast Guard) published the world's first ever electronic chart (Tokyo Bay to Ashizuri Misaki(Cape Ashizuri)) in March 1995. Since then, with developments in computer technology, equipment with advanced functions known as the Electronic Chart Display and Information System ("ECDIS") has been developed and this is where we stand today.

Before the introduction of ECDIS, a paper nautical chart was used to create a navigation plan. A Gyro compass, radar and radio navigation equipment were used calculate the ship's position, and this information was transcribed on the paper chart. Also, with the appearance of the GNSS (Global Navigation Satellite System, GNSS being the generic term for the satellite positioning system known as GPS (USA), GLONASS (Russia), and Galileo (EU)), we were able to obtain highly accurate position information according to Latitude and Longitude , but the position of the vessel continued to be checked using a paper nautical chart.

It used to be that the navigation plan was prepared and the vessel position checked in order to create the nautical chart table. Nowadays, when ECDIS is compulsory, the vessel is manoeuvred from the conning position while reading the displayed nautical chart and vessel position information. Further, although there are no plans to scrap the paper chart, navigation without the use of the paper chart is becoming a reality. From the viewpoint of the Conning Officer (Master/Officer), this is considered to be a major revolution in the use of nautical charts. However, basic manoeuvring has not changed with the appearance of ECDIS, and this is carried out using a system made up of the 3 elements shown in Table 1.

Sponsored by FURUNO
Electronic Chart Display and Information System (ECDIS)
FMD-3300

Sponsored by FURUNO
GNSS
GP-170

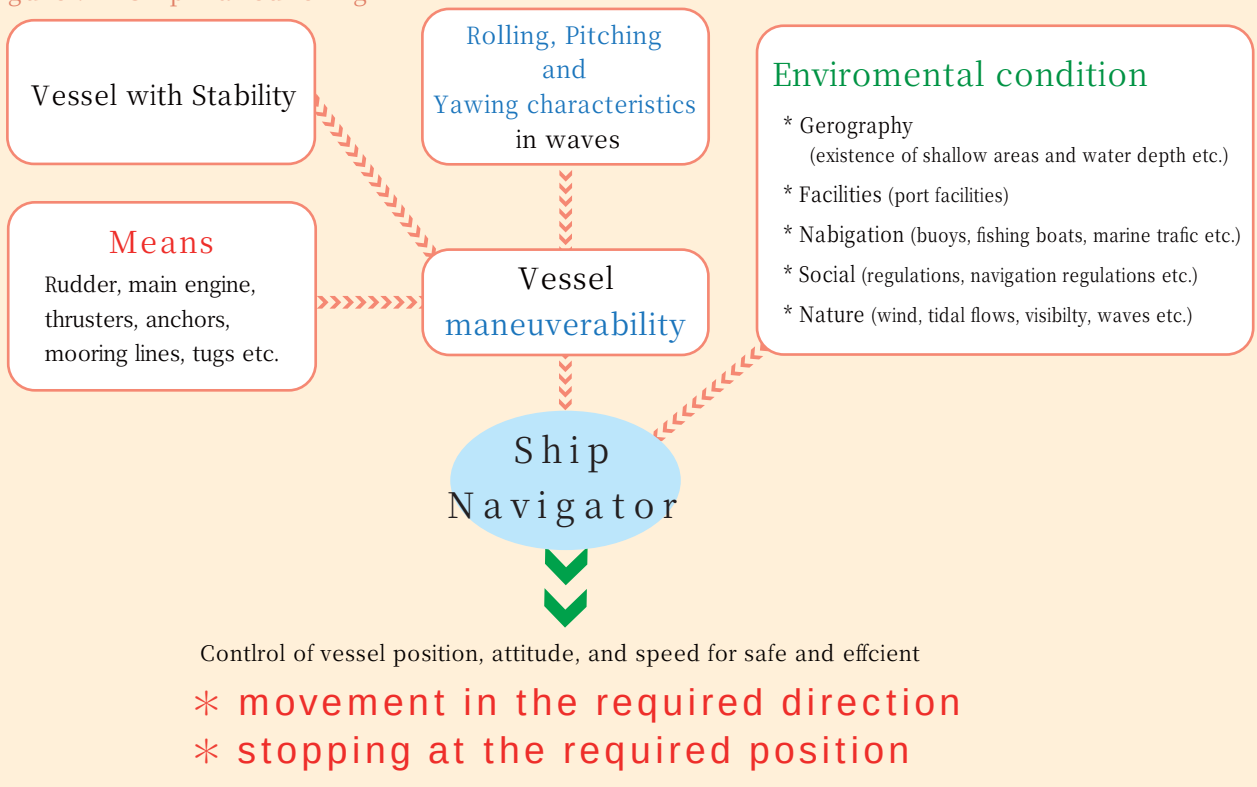
In the words of Kinzo Inoue, the basic principle of manoeuvring or vessel handling is the knowledge that "a vessel floats in water and returns to its original position after a list. It is manoeuvered with the assistance of the rudder, main engine(s) and other auxiliary equipment, using knowledge of the rolling, pitching and yawing characteristics of the vessel in waves. In handling the vessel it is necessary to consider the effects of environmental conditions while controlling the position of the vessel, its attitude, and its speed, to move the vessel in the designed direction in a safe and efficient manner, and to stop at the intended position (Theory and Practice of Ship Handling, Kinzo Inoue, Honorary Professor, Kobe University).", and a summary of this is shown in Figure 2.

Table : 1 Constituent Elements of the Maneuvering System

Ship navigation system	Ship navigation environment	Geomorphic environment	The environment consisting of the terrain, structures, and water depth which are characteristic to that location
		Natural environment	The environmental changes which occur over time and are caused by nature. Factors such as weather, sea conditions, seasons, day and night
		Traffic environment	This is an artificially created environment, and consists of artificial elements such as other vessels, sailing route, navigational aids and traffic rules.
	Vessel	Hull	Size and draft of the vessel
		Motion controllers	Equipment used to move the vessel (such as main engine, steering gear, and nautical instruments)
		Motion performance	Factors such as course, speed, turning circle
	Operator	Operating technology	Person who has the skills to operate the vessel, and uses it to control the vessel
		Operating system	Factors such as navigational watch, bridge manning plan

From this viewpoint, ECDIS is just one part of the system to provide information, and excessive trust in the information generated by ECDIS could result in a drop in the operating skills of the Conning Officer, or cause the Conning Officer to overlook vital information. If unmanned vessels make an appearance in the future, different rules may apply, but in the present situation in which the vessel is operated by Ship's crew who are on board, we need to go back to basics and consider the ECDIS configuration and how to handle it for the task of manoeuvring.

Figure : 2 Ship Maneuvering



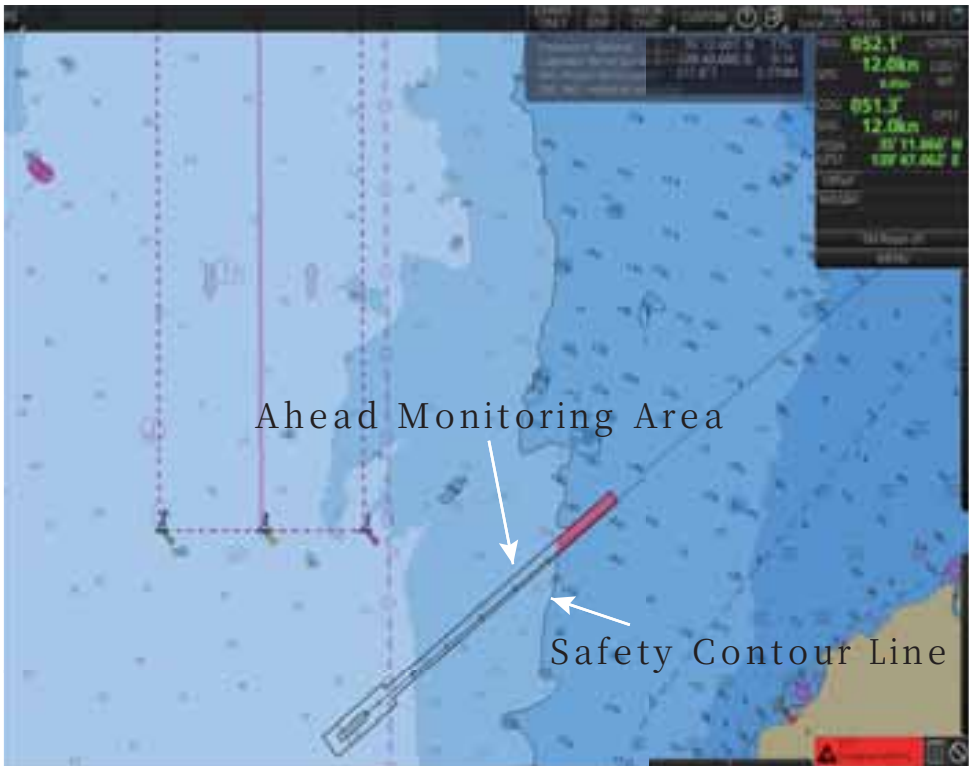
Chapter 1 Electronic Chart Display and Information System (ECDIS)

1－1 ECDIS Functions

The definition in Performance Standards for ECDIS (Resolution MSC.232(82), adopted on 5 December 2006 (hereinafter referred to as MSC.232(82): See Attachment ①), 3. Definition 3.1, “Electronic Chart Display and Information System (ECDIS)) means that a navigation information system with adequate back-up arrangements can be accepted as an up-to-date chart as required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended. ECDIS complies by displaying selected information “from a System Electronic Navigational 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.” .

In other words, ECDIS is an information system for navigation that is not only an alternative to a paper chart, but has various functions such as checking the position of the vessel using GNSS, reusable navigation planning (Route Planning), and showing the bearings and distance to the course deviation point or course alternating point from the set route (Route Monitoring). It can also warn the Master or crew that the vessel is crossing the set safety isobaths, or approaching a hazardous object (see Ref. 3,4 and 5).

Ref. 3　Sample of Preventative Alarm for Grounding (Crossing Safety Contour Line)

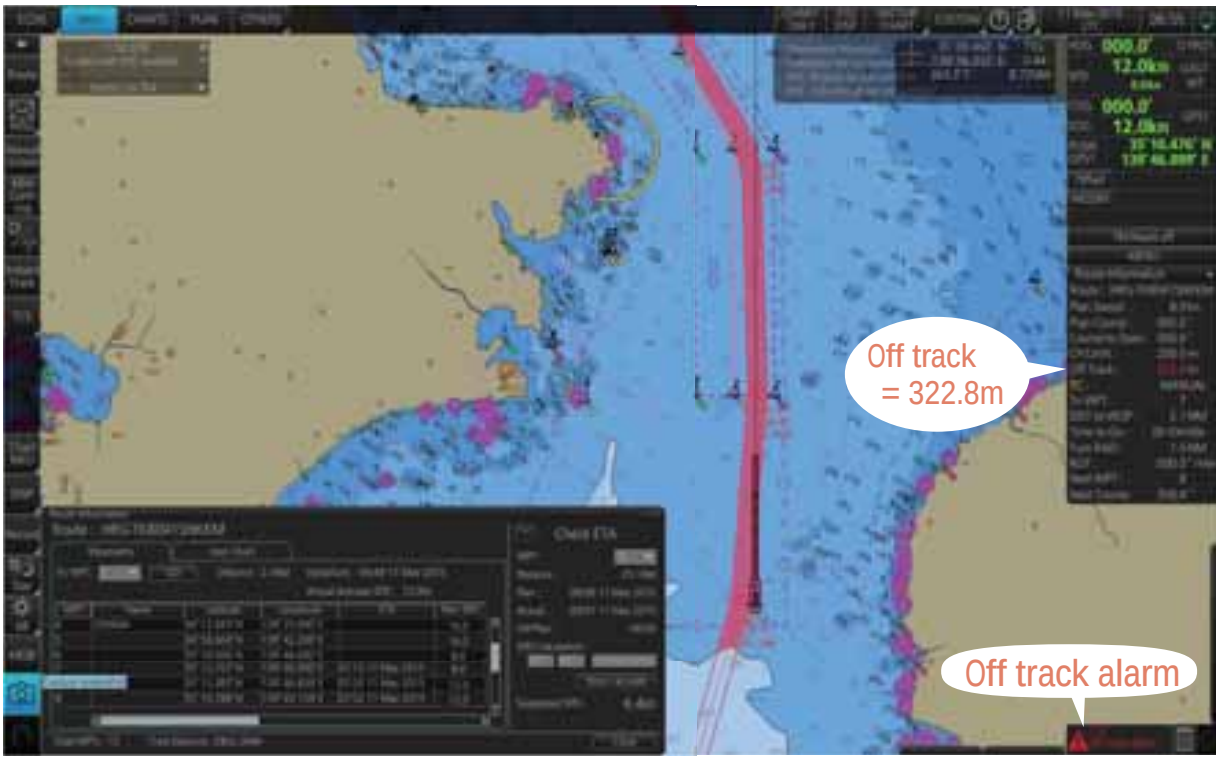


Sponsored by Japan Marine Science Inc.

Ref. 4　Sample Display of Safety Check under Voyage Planning
(Red Color route : Voyage Planning Route pass through Warning area (special condition area)

Sponsored by Japan Marine Science Inc.

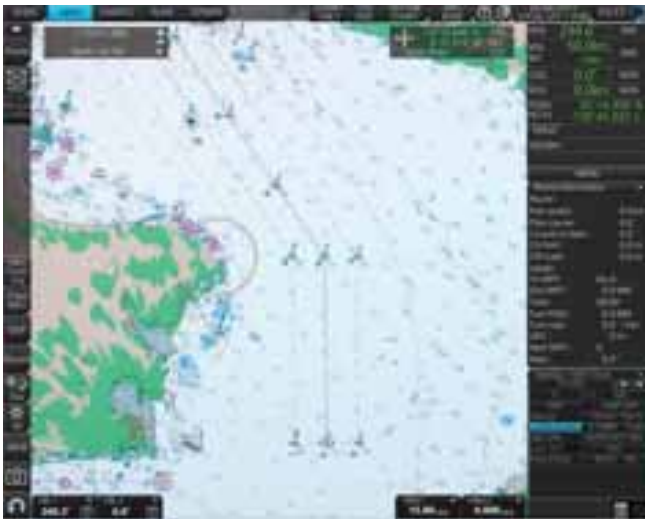
Ref. 5　Sample Display of Route Monitoring
(Off Track Alarm : Ship's position is 328m right side to Planned Route.)
(Shoulder width of Planned Route : 200m, Total =400m Left and Right)



Sponsored by Japan Marine Science Inc

ECDIS also has additional functions such as AIS (Automatic Identification System) and can capture radar information and use it to display information on other vessels (Information from ARPA (Automatic Radar Plotting Aids)) and superimpose radar images. This has been summarised in diagrammatic form in Figure 6.

Sponsored by FURUNO
AIS
FA-170



Sponsored by FURUNO
Radar Overray

Figure : 6 Function of ECDIS

Basic Function

- Display of Nautical Charts
- Own Ship's Position data
- Display of Ship's Co/Speed
- Route Planning
- Route Monitoring
- Alarm and and Warning Display
- Record of Voyage

Additinal Function

- Display of Other Vessels Information Data (ARPA Target Tracking)
- Display of AIS Information
- Radar Overlaid display
- Auto Pilot
- Display of Weather Information

etc..

MSC.232(82) sets out the scope of ECDIS in the following terms: “The primary function of the ECDIS is to contribute to safe navigation.”

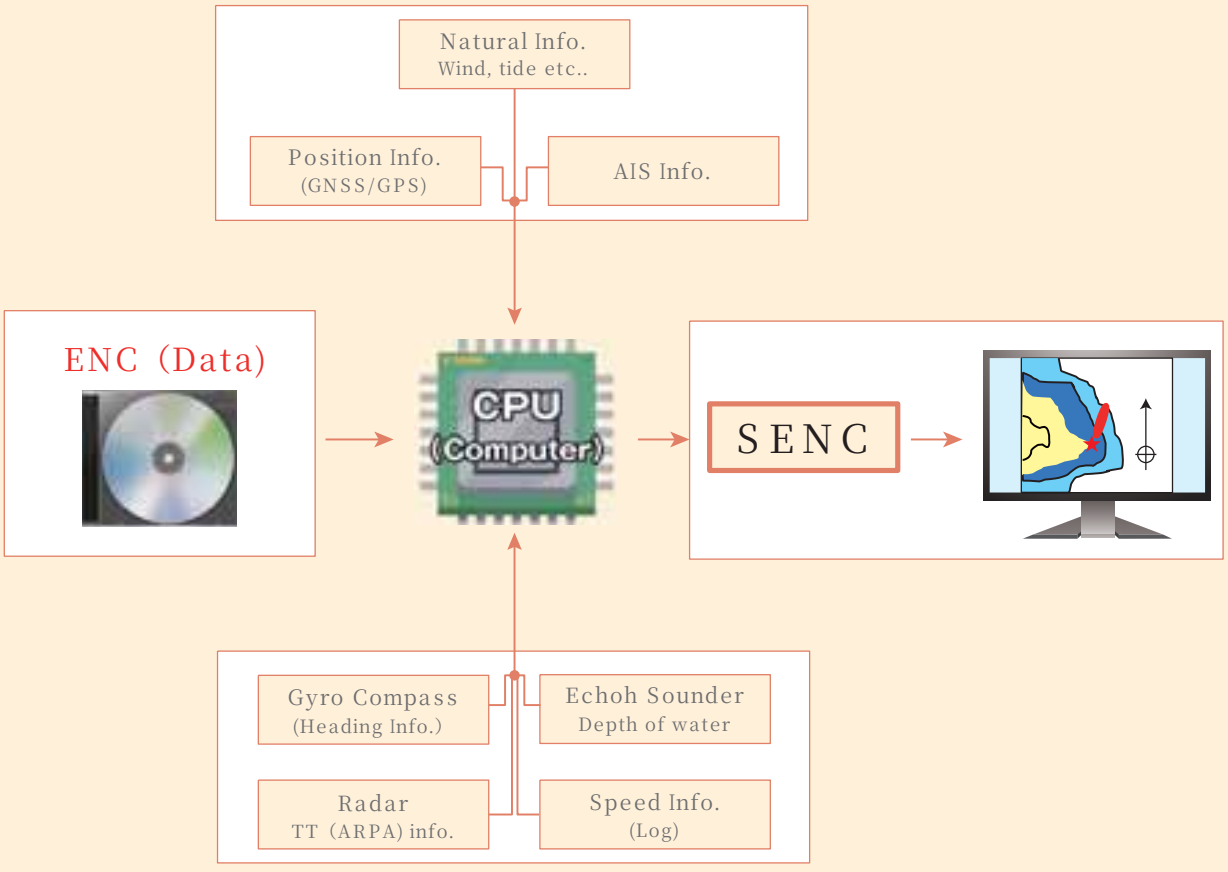
1－2　ECDIS Overview

The configuration of ECDIS is shown in Figure 7. Instead of the earlier paper chart, there is an electronic navigational chart: ENC. According to MSC232(82) 3.2, “Electronic Navigational Chart (ENC) means the database, standardised as to content, structure and format, issued for use with ECDIS by or on the authority of a Government-authorised Hydrographic Office or other relevant government institution, and conforming to IHO standards.”, the IHO being the International Hydrographic Organization.

The ENC is generally distributed through electronic media such as CDs/DVDs and may be bought from a chart distributor. Once the ENC is installed in the ECDIS, it is converted into a System ENC (SENC), and it is finally displayed on the screen.

A SENC is a database containing all the ENC contents and updated information created in the nautical chart format by the ECDIS manufacturer.
In other words, SENC is a source of information to implement display and other navigation related functions in ECDIS, and it is accepted as being equivalent to the latest version of the paper chart.

Figure : 7　Structure of ECDIS



Chapter 2 Overview of Rules Regarding Electronic Charts

2－1 Nautical Charts for Navigation

Nautical charts for navigation are special-purpose maps which have been designed to meet the requirements of navigation at sea, and show diverse information such as the depth of water, material on the sea bed, land terrain, elevation of structures, the shape and characteristics of the beaches, hazardous objects and beacons, etc. In other words, nautical charts for navigation provide images of the relevant information to the navigator for safe navigation.

Until the arrival of electronic charts, information was provided in analogue format using paper charts, but now information is also available in digital format (Electronic Navigational Charts: ENC).
However, in some zones in the world, nautical charts based on old survey results are still used, and this affects the geodetic system in and positional accuracy of the nautical charts. Not all geodetic systems are accurately defined, and there are some inaccurate geodetic systems. In such ocean areas, please be aware that paper charts (and Raster nautical charts: See 3-3 for details) are not suitable for navigation using GNSS. This alert is being issued as a guideline in the IMO Ship navigation subcommittee circular “Ref. T2-OSSHE/2.7.1 SN.1/Circ.255 24 July 2006, Additional Guidance on Chart Datums and the Accuracy of Positioning on Charts”. (See Attachment ②)

2－2 The International Convention for the Safety of Life at Sea (SOLAS) Chapter V

SOLAS V/2 Regulation 2 Definitions

2.2 “ Nautical chart ”or“ Nautical publication ”is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government-authorised Hydrographic Office or other relevant government institution and is designed to meet the requirements of marine navigation.*

* Refer to appropriate resolutions and recommendations of the International Hydrographic Organization concerning the authority and responsibilities of coastal States in the provision of charting in accordance with regulation 9.

SOLAS V/19 Regulation 19　2 Shipborne navigational equipment and system

(Old)

2.1　All ships irrespective of size shall have:

2.1.4　Nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage. An electric Chart display and information system(ECDIS) may be accepted as meeting the chart carriage requirements of this subparagraph:

(Amended)

2.1　All ship irrespective of size shall have:

2.1.4　Nautical charts and nautical publications to plan and display the ship's route for the intended voyage and to plot and monitor positions throughout the voyage. An electronic Chart display and information system (ECDIS) is also accepted as meeting the chart carriage requirement of this subparagraph. Ships to which paragraph 2.10 applies shall comply with the carriage requirements for ECDIS detailed herein;

2.1.5　Back-up arrangements to meet the functional requirements of subparagraph, 4, if this function is partly or fully fulfilled by electronic means.*

* An appropriate folio of paper charts may be used as a back-up arrangement for ECDIS. Other back-up arrangements for ECDIS are acceptable (see appendix 6 to resolution A.817(19) as amended.

Regulation 27 Nautical Charts and nautical publications

Nautical charts and publications, such as sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage, shall be adequate and up to date.

Chapter V of SOLAS defines the requirements for carriage of nautical charts in shipping vessels.
The above 3 rules indicate that the following requirements are met by the nautical charts carried in vessels corresponding to the vessel class.

- Official paper charts which have been kept up to date should be carried, or
- The latest version of the electronic navigational charts (ENC) should be used to provide a type approved ECDIS supplemented by appropriate backup measures (in accordance with the requirements to meet IMO performance standards).

2 — 3　Fitting Requirements

With the revision in Chapter V Rule 19 of SOLAS, which was adopted in June 2009, and came into effect on 1 January 2011, ECDIS is required to be used for each vessel category and size as shown in Table 8.

Table : 8　ECDIS Installation Schedule

ECDIS　Installation Schedule

Category	Kind of ship	G/T	Deadline of installation
New Build Vessels	Passanger	More than 500G/T	
	Tanker	More than 3,000G/T	
	Other than Tanker	More than 10,000G/T	
	Other than Tanker	3,000G/T～ Less than 10,000G/T	
Current Vessels	Passanger	More than 500G/T	
	Tanker	More than 3,000G/T	
	Other than Tanker	More than 50,000G/T	
	Other than Tanker	20,000G/T～ Less than 50,000G/T	
	Other than Tanker	10,000G/T～ Less than 20,000G/T	

＊ New Build vessel (Pax・Tanker) : Builded after 1st July 2012
＊ New Build vessels (Other than Tanker) : Builded after 1st July 2013
＊ Current vessel (Pax・Tanker) : Builded before 1st July 2012
＊ Current vessels(Other than Tanker) : Builded before 1st July 2013

Chapter 3 Electronic Charts

An understanding of nautical chart data is necessary in order to use ECDIS. ECDIS is a system which displays electronic charts, and unless the user understands the kind of data displayed, the user cannot use ECDIS effectively. This chapter describes the basics of the electronic charts displayed in ECDIS.

3－1 Differences between the Electronic Chart System (ECS) and Electronic Chart Display and Information System (ECDIS)

First, it is important to understand the difference between ECS and ECDIS as systems which display electronic charts. (See Figure 9)

・ECS: Electronic Chart System

Equipment that can display electronic charts, but does not meet the IMO performance standards. (For example, if electronic charts are stored and displayed from a notebook PC, then that notebook PC is an ECS.)

・ECDIS: Electronic Chart Display and Information System

ECDIS refers to equipment that meets the performance requirements of IMO, and has obtained type approval from the flag state.

Figure : 9 ECS and ECDIS

ECS	:	Equipment that does not meet the IMO performance standards
ECDIS	:	Equipment that meets the IMO performance standards, and whose models have been certified by the flag state

3－2 Vector nautical Charts

A vector nautical chart is a digital database created by converting the positional information of all objects (points, lines, planes) displayed on a paper nautical chart into numerical form as co-ordinates. Therefore, objects displayed on a paper nautical chart are associated with geographical information.

Each page on a paper nautical chart is a square known as a “Cell”, which is enclosed by specific latitudes and longitudes. A cell is classified in 6 ways according to the purpose of navigation. (See Table 10. This classification has been done by the Hydrographic and Oceanographic Department, Japan Coast Guard, and the cell size as well as the scale of the nautical chart are left to the hydrographic organisation in each country.)

Table : 10　Category of Nautical Chart Scale

Category of Nautical Chart Scale

Purpose of Voyage	Scale	Cell Size
Overview	1 : 1,500,001　～	8 degree, 25 degree
General Navigation	1 : 300,001～1 : 1,500,000	4 degree
Coastal Navigation	1 : 80,001～1 : 300,000	1 degree
Approach	1 : 25,001～1 : 80,000	30 minutes
Harbour	1 : 7,501～1 : 25,000	15 minutes
Berthing	～　1 : 7,500	15 minutes

A vector chart which is an official nautical chart is known as an ENC (Electronic Navigational Chart), and its geodetic system is standardised as the world geodetic System : WGS-84.
As stated earlier, ENCs are official vector charts published by governmental authorities, or authorised hydrographic authorities, or other related government institutions, and are edited and codified based on the “IHO Specifications for the IMO Performance Standards for ECDIS”. They include a description of the data format, product specification for the production of ENC data, and an updating profile (S-57)” as specified by the IHO.
All vector charts other than ENCs are unofficial charts, and since they do not meet the carriage requirements of SOLAS nautical charts, they are not accepted as the basis information for navigation.
The geodetic system is based on WGS-84 as stated above, and it has direct compatibility with the Global Navigation Satellite System (GNSS).
Against this background, since ENC is a database which has been converted to numerical form based on the data in paper charts, the datum levels and units have been compiled in the same manner as a paper chart, but there have been considerable omissions in terms of inland areas found in the paper charts, such as the land terrain and geographical (natural and man-made) features required for piloting (or ground reference navigation).

Further, officially-updated information for mariners is usually provided in an “Electronic Notice to Mariners”, which is distributed in digital form, and can be downloaded from the website or provided as an Update CD/DVD.
As of August 2015, ENCs for almost all ocean areas have been created by the hydrographic authorities of various countries, but 100% worldwide coverage has not yet been achieved. When navigating through such ocean areas, Raster Navigational Charts (RNC) must be installed, as described later. In ocean areas where there are no RNCs either, paper charts need to be used.
In ocean areas covered by ENC, the IHO has provided an interactive web catalogue (https://www.iho.int), which shows the publication status of ENC worldwide.(See Ref.11)

Ref. 11 IHO ENC Catalogue Sample

3 — 3 Raster Navigational Chart

A Raster Navigational chart refers to image data which has been obtained by capturing the existing paper chart using a scanner. The RNC is composed of pixels which have been generated in order to convert the information to image data, but this has not been associated with geographical information in the way that vector charts have. For example, the RNC has limitations such as the fact that geographical data such as water depth cannot be used to set alerts.

At present, in case of ARCS (Admiralty Raster Chart Service) provided by the UK Hydrographic Department, all the data is managed using the same number as the respective paper charts, and the scale used is the same as the paper charts.
Since there are ocean areas for which the geodetic system being used is not WGS-84, note that the geodetic system may be different from the one displayed by the position sensors (GNSS data) during use.
A Raster chart which is published by the government, hydrographic authorities authorised by the government, or other related government institutions, or officially published under their authority, similar to a vector chart, is known as a RNC (Raster Navigational Chart), and the others are all unofficial nautical charts. In short:

- A RNC is a type of copy of an official paper chart
- A RNC is created in accordance with international standards specified by the IHO
- A RNC is periodically kept up to date using official information, with updates provided/distributed in digital form.

In 1998, the IMO recognised the fact that it would take several more years to complete ENCs worldwide, and as a result, they are carrying out revisions to add the Raster chart display system mode (RCDS) to the ECDIS performance standards of IMO. (Further, as of the year 2016, worldwide coverage of ENCs has not yet been achieved.)

3—4 Differences between the Raster Chart Display System (RCDS) and Electronic Chart Information Display System (ECDIS)

As stated in 3-1, RNC and paper charts are used for navigation in areas not covered by ENC. Regarding the differences between RCDS and ECDIS, there is a requirement from IMO in the "IMO Safety of Navigation circular No. 207" (See the Attachment ③) that if ECDIS is used in RCDS mode,"A suitable set of paper charts which has been kept up to date "must be used in that ocean area.

A summary of the features of RNC is given below. Users are required to fully understand these features.(See Ref.12-1 and 12-2)

1 That RNC is a type of copy of an official paper chart.
As stated in 3-3, RNC is displayed in ECDIS by scanning a paper chart. Therefore, the information displayed is the same as the paper chart.

2 However, since it is not associated with geographical information in the way that a vector chart is, it cannot be used, for example, to set alerts based on geographical data such as water depth. (It is not possible to set grounding alerts).
If the user wants to include alert functions similar to a vector chart, he must manually enter the alert data.

3 A vector chart is a digital database created by converting the position information on all objects (points, lines, and planes) in the area into numerical form as co-ordinates, and hence detailed information on each object (for example, information on water depth, buoys, lighthouses, etc.) can be selected and checked. A Raster chart, however, only contains information from the displayed drawings.

Ref. 12—1 RNC Sample

RNC : Copy of Paper Chart

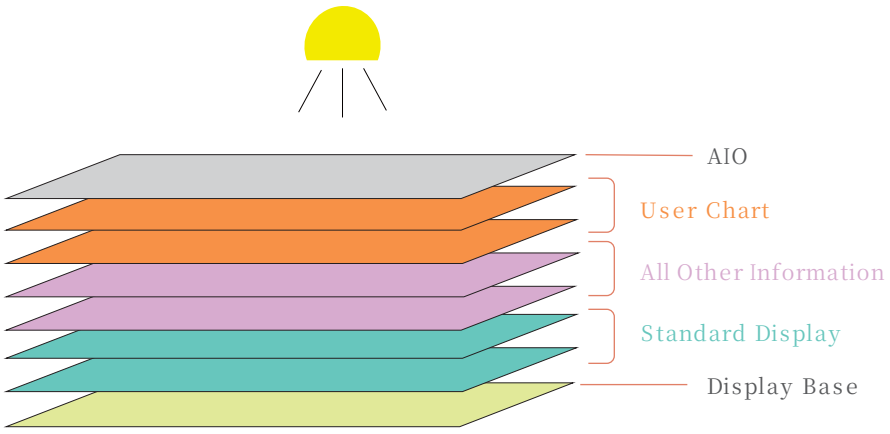
Ref. 12—2 ENC Sample

ENC : Select Data for Display

Sponsored by FURUNO

An ENC uses a technique known as “Layering” to display the chart on the screen. This is an image obtained by displaying multiple transparent sheets with different information superimposed on a single screen. (See Figure 12-3)

Figure: 12－3 ENC Information Layer (Image drawing)

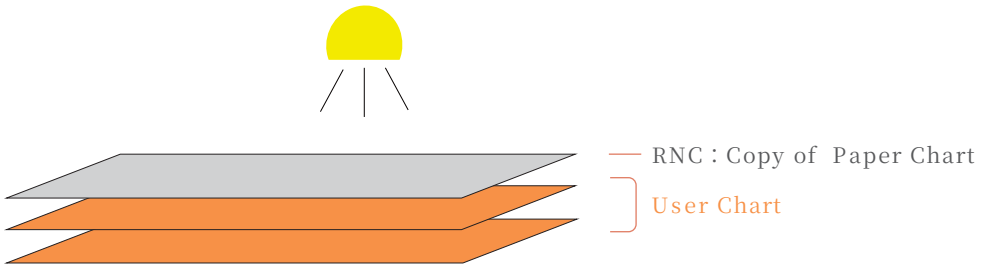


AIO : Admiralty Information Overlay
User Chart : Manual Input Information by User
Standard Display : Standard Display Information
All Other Information : All Other information Other than Standard Display
Display Base : Basic Display Information(Parmanent Information on Display)

On the other hand, since RNC is a copy of a paper chart, it does not use the layering technique, but is viewed as an image on which a single electronic file is displayed, with superimposed on it other charts manually entered by the user. (See Figure 12-4)

For example, areas such as a no go area or “Captain call” position may sometimes be pencilled on a paper chart, and such a chart with additions made by hand is known as a user chart.

Figure : 12－4 RNC Display (Image Drawing)

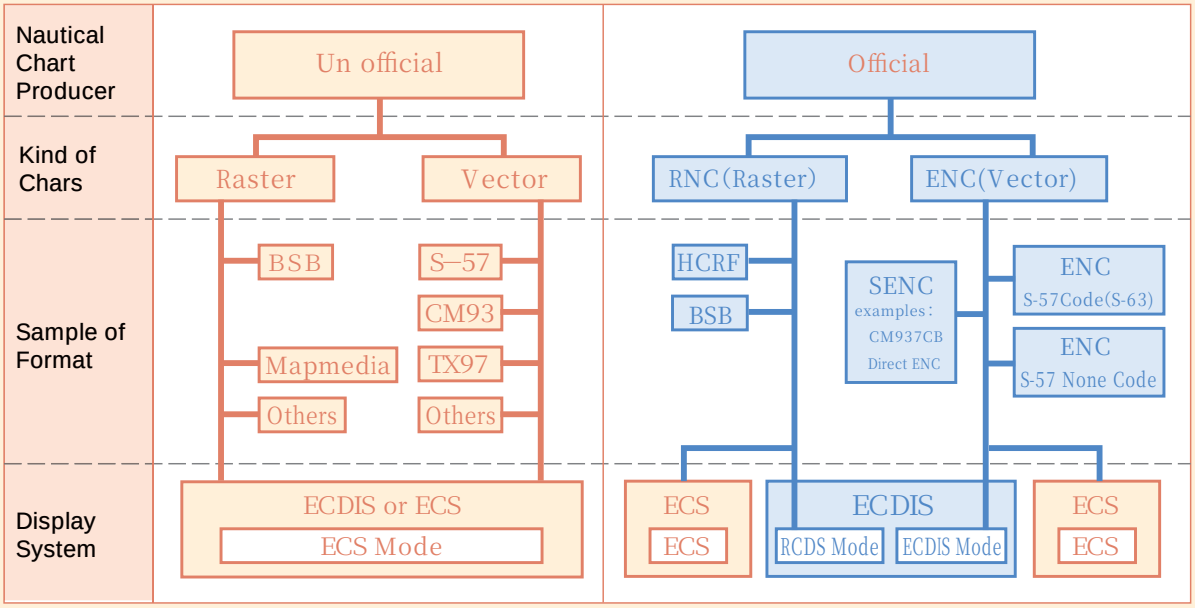


RNC : Raster Navigational Chart
User Chart : Manual Input Information by User

3 — 5 Classification of Official Charts and Unofficial Charts

There is considerable confusion regarding the name for the format when providing/distributing electronic charts. Figure 13 has been created in an attempt to clear up this confusion.
However, as can also be observed from Figure 13, it is clear that the same format is used to provide/distribute both official and unofficial nautical charts.

Figure : 13 Official・Unofficial Nautical Chart format (Sample)



Note: In an unofficial source, even an ECDIS system will not switch to the ECDIS display mode. The portion shown in blue in Figure 13 is ECDIS.

Therefore, to determine whether or not the nautical chart is official, it is important to use the source documents since it is difficult to determine this using the format information. The creator must determine the situation and purpose for which the relevant nautical chart information is to be used, and must finally probe whether the combination of the relevant nautical chart information and the specific system functions operates as the ECDIS, or as a simple ECS.

3—6 Backups

Although a variety of electronic systems exist, there is no completely “Fail-safe system” which guarantees that the systems will never malfunction. Therefore, the provision of a backup system is required from the viewpoint of risk management. In IMO performance standards, the entire ECDIS system must have a complete and completely separate back-up. The following is stipulated with regard to back-ups :

- An independent facility which can ensure complete continuity of ECDIS functions in order to ensure that system malfunction does not lead to a gravely critical situation
- A means to carry out safe navigation using the remaining navigational components in case of ECDIS malfunction.

The IMO backup standards mentioned above refer to basic matters, with room for considerable flexibility, but the options for backup functions which are generally approved are the following :

- A back-up ECDIS which is connected to an independent power source, and can be used to enter separate GPS positioning information.
- A set of paper charts which are suitable and kept up to date for the intended voyage.

3－7　Approval by Port State Control (PSC)

When a vessel plying on international routes enters a certain port, it is subject to Port State Control (hereinafter referred to as PSC). PSC is enforced by the PSC Officer for that port with reference to the rules of the flag state and international conventions and rules, and nautical charts are one of the inspection items.

PSC in the EU is enforced according to the guidelines defined in the Paris MOU. However, ECDIS guidelines describe the inspection by the PSC Officer in terms of whether the vessel is using the proper electronic charts, based on the requirements of the SOLAS Convention. The inspection items are as follows :

Check

- ☑ Whether the vessel is in possession of documents showing that its ECDIS is in compliance with IMO performance standards. If these documents are not on board, the PSC Officer can ask the flag state for confirmation that this system meets their legal requirements. (Certificates for type approval, etc.)
- ☑ Whether this system is mainly used for navigation. Check whether ECDIS is being used in the ECDIS mode or RCDS mode, or in both modes. (Fact-finding)
- ☑ Whether written documentation has been issued for this vessel in order to use ECDIS. (Whether the relevant documents are on board the vessel)
- ☑ Whether the master and duty officer can present proper documents to prove that they have undergone generic training and model-wise familiarisation training on ECDIS. (Whether the master and officers are in possession of certificates of completion of training. See Ref.14)
- ☑ Whether the ENCs (and RNCs) to be used on the intended voyage have been kept up to date.
  (Whether they have definitely been updated using the provided/distributed update information)
- ☑ Whether the vessel is equipped with approved backup measures which can safely transfer the ECDIS function if there is an ECDIS malfunction, and ensure safe navigation using the remaining navigation components. Also, whether the backup ECDIS is operating in the same manner as the main ECDIS, or if paper nautical charts are operating as the backup, whether nautical chart corrections have been correctly performed, and recorded.

Ref.14　ECDIS Familialization Training Certificate Sample