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INTERNATIONAL HYDROGRAPHIC ORGANIZATION

FACTS ABOUT ELECTRONIC CHARTS AND CARRIAGE REQUIREMENTS

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IHO

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INTRODUCTION

The International Convention for the Safety of Life at Sea (SOLAS) includes a requirement for all ships to carry up-to-date nautical charts and publications for the intended voyage. Progressively from 2012, the chart carriage requirement for certain classes of vessels is to be satisfied by electronic means using an Electronic Chart Display and Information System (ECDIS).

Feedback from those involved in the use of charts and electronic charting systems including manufacturers, distributors, users, ship owners, regulatory authorities, pilots, harbour authorities and others indicates a requirement to provide guidance on the regulations and the status of equipment that is available in the market today. In particular the differences between the various types of equipment and the differences between the various types of chart data offered to users are unclear with respect to the regulations in place.

This document has been produced to help clarify some of the uncertainties. It is not intended to replace or amend national or international rules and regulations. Readers should always refer to the relevant national administration or Flag State for the latest detailed information.

This document consists of a number of interrelated sections. This first section contains information on various aspects of electronic charts and electronic chart display systems in the form of questions and answers. The main emphasis is on what can be used to satisfy the SOLAS carriage requirements for charts.

Section 1: Overview of electronic charting and regulations

Section 2: A list of points of contact for detailed information on Flag State Implementation of ECDIS

Section 3: ECDIS Training

Section 4: Technical aspects of electronic charts

Sedtion 5: ECDIS cyber security

Section 6: Appendix: References, glossary, further reading

This document may be downloaded from the IHO website at http://www.iho.int

Links to pages on the IHO web site containing related documents can be found in the References section.

EDITION FEEDBACK

Feedback from readers on any aspect of the document is welcome.

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DOCUMENT HISTORY

This document was originally produced by Hydrographic Offices from the two Regional ENC Coordination Centres (RENCs), PRIMAR and IC-ENC. In 2008 a 2nd edition of the publication, produced by the PRIMAR and IC-ENC Joint Information Working Group (JIWG), was adopted by the IHO. Following further revision it was published in January 2010 as IHO publication S-66. Edition 1.1.0 has been prepared by the IHO ENC Standards Maintenance Working Group (ENCWG) in order to correct and update content that has changed since Edition 1.0.0.

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SECTION 1: OVERVIEW OF ELECTRONIC CHARTING AND REGULATIONS

Regulations

The International Maritime Organization (IMO) is the United Nations organization that is concerned with maritime transportation. The 1974 Convention for the Safety of Life at Sea (SOLAS), together with subsequent amendments, has been adopted by the Member States of the IMO. Chapter V of SOLAS specifies the requirements for the navigational equipment to be used on board ships entitled to fly the flag of a party to the SOLAS Convention.

IMO Member States are obliged to adopt IMO rules and regulations, such as those in SOLAS, into their national legislation. However, only when the requirements of the Convention have been incorporated into national legislation do they take effect for the individual ships registered by that State. This process of incorporation into national legislation may vary from a few months to several years.

The State in which a ship is registered and hence which flag it is flying is known as the Flag State. It is the national maritime administration representing the Flag State that controls the ship's adherence to the SOLAS carriage requirements (Flag State control).

The national maritime administration is also responsible for Port State control. Ships arriving at a port may be subject to Port State control by local officials (Port State Control Officers – PSCO's). Port State control is based on Flag State regulations and international agreements. Port States cooperate within regions to apply consistent standards; for example, the European nations and Canada cooperate under the umbrella of the Paris Memorandum of Understanding (Paris MOU).

What are the IMO requirements that apply to the carriage of nautical charts?

What is a nautical chart?

Nautical charts are special purpose maps specifically designed to meet the requirements of marine navigation, showing amongst other things depths, nature of the seabed, elevations, configuration and characteristics of the coast, dangers, routes, maritime limits, and aids to navigation.

Nautical charts provide a graphical representation of relevant information to mariners for planning and executing safe navigation.

Nautical charts are available in analogue form as paper charts, or digitally as electronic charts.

The requirements for the carriage of nautical charts are laid down in SOLAS Chapter V.

The relevant regulations are:

- Regulation 2, which defines the nautical chart;
- Regulation 19, which specifies the equipment (including charts) to be carried on different types of ships; and
- Regulation 27, which specifies the requirement to keep charts and publications up to date.

IMO SOLAS V/2 1974 (as amended):

*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, authorized Hydrographic Office or other relevant government institution and is designed to meet the requirements of marine navigation.**

> *Footnote to regulation 2.2*
>
> ** 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.*

IMO SOLAS V/19 1974 (as amended):

19.2.1 All ships irrespective of size shall have:

19.2.1.4 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 requirements of this subparagraph. Ships to which paragraph [2.10] applies shall comply with the carriage requirements for ECDIS detailed therein;

19.2.1.5 back-up arrangements to meet the functional requirements of subparagraph 2.1.4, if this function is partly or fully fulfilled by electronic means;*

> *Footnote to regulation 19.2.1.5*
>
> ** An appropriate folio of paper nautical 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).*

IMO SOLAS V/27 (as amended):

Nautical charts and nautical 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.

The three regulations referred to above show that depending on the class of vessel, the carriage requirement for charts can be fulfilled by:

- Carriage of official and up to date paper charts; or
- Carriage of a type-approved ECDIS (in accordance with the requirements of the IMO ECDIS Performance Standards) supplemented by an appropriate back-up arrangement, and up to date Electronic Navigational Charts (ENC).

What is an electronic chart display system?

An electronic chart display system is a general term for a configuration of electronic equipment, software, and nautical chart data that is capable of displaying a vessel's position superimposed on a chart image.

There are two classes of electronic chart display systems. The first is an ECDIS (Electronic Chart Display and Information System), which can meet IMO/SOLAS chart carriage requirements. The second is an ECS (Electronic Chart System), which can be used to assist navigation, but does not meet IMO/SOLAS chart carriage requirements.

ECDIS

ECDIS equipment is specified in the IMO ECDIS Performance Standard (see Resolution MSC.232(82) as follows:

Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention as amended ………".

Where the term ECDIS is used in this document, it means those navigational electronic chart systems, that have been tested, approved and certified as compliant with the IMO ECDIS Performance Standard and other relevant IMO Performance Standards and thus are compliant with the ECDIS chart carriage requirements contained in SOLAS Chapter V.

The IMO MSC.1/Circ.1503 (as amended) Circular on "*ECDIS - Guidance for Good Practice*", adopted at MSC 95 in June 2015, provides useful references on ECDIS matters.

ECS

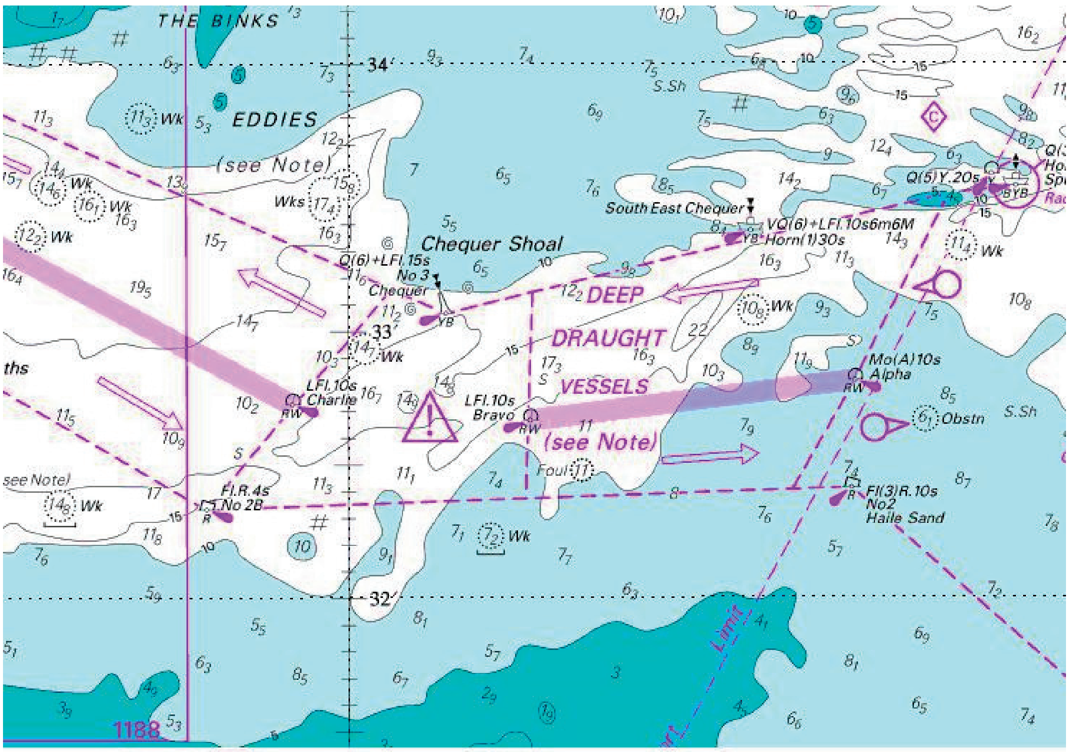
ECS is specified in ISO 19379:2003[1] as follows:

ECS is a navigation information system that electronically displays vessel position and relevant nautical chart data and information from an ECS Database on a display screen, but does not meet all the IMO requirements for ECDIS and is not intended to satisfy the SOLAS Chapter V requirements to carry a navigational chart.

ECS equipment ranges from simple hand held GPS enabled devices to sophisticated stand-alone computer equipment interfaced to ship systems.

What kinds of electronic charts are available?

There are two types of electronic chart – raster charts and vector charts. A raster chart is a scanned and passive image of a paper chart, whereas a vector chart is a digital database of all the objects (points, lines, areas, etc.) represented on a chart. See Section 4 for further technical details.



Example of a raster chart

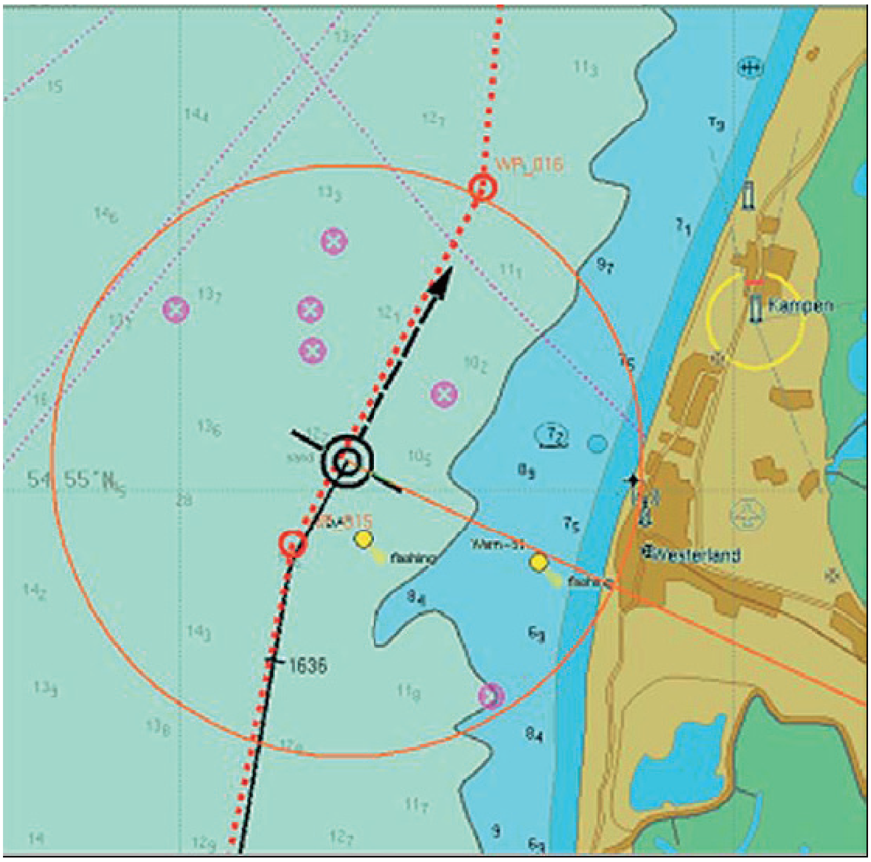
[1] See http://www.iso.org/iso/catalogue_detail.htm?csnumber=33801

What are official charts?

According to SOLAS V (see above), charts issued *by or on the authority of a Government, authorized Hydrographic Office or other relevant government institutions* are official and may be used to fulfil carriage requirements (provided they are kept up to date).

All other nautical charts are by definition not official and are often referred to as unofficial or private charts. These charts are not accepted as the basis for navigation under the SOLAS Convention.

There are two kinds of official digital nautical charts commonly available; Electronic Navigational Charts (ENC) and Raster Navigational Charts (RNC).



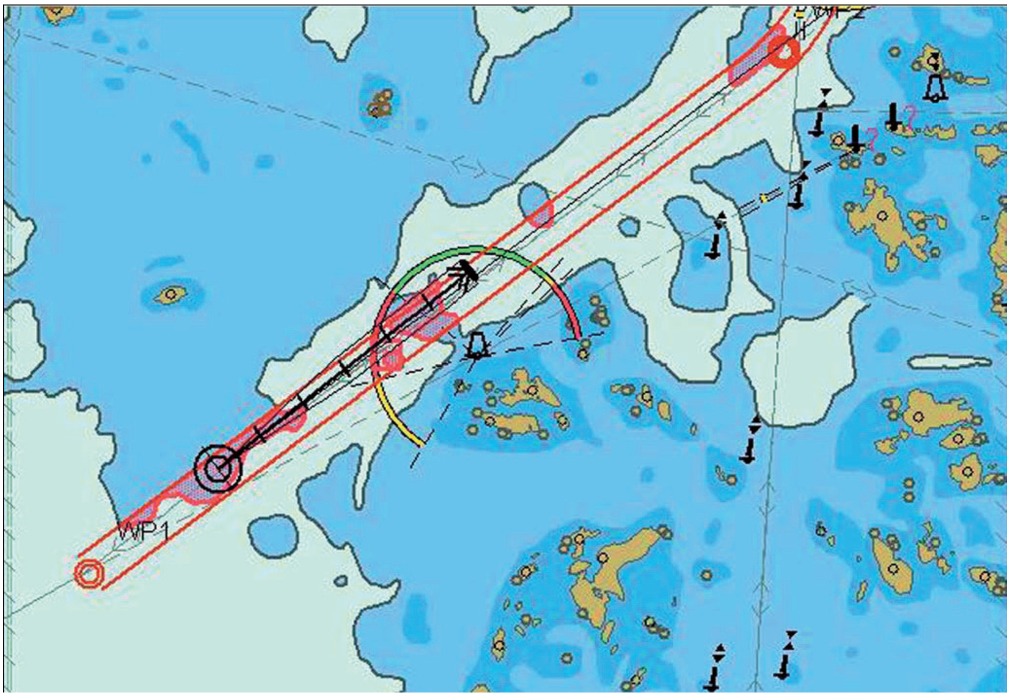
Example of a vector chart with vessel's position in the centre

What is an ENC?

ENC stands for "Electronic Navigational Chart". An ENC is a vector chart, issued by or on behalf of a Governmental body (see "*official chart*" above) that complies with the relevant IHO standards. Any other vector chart data is unofficial and therefore does not meet the SOLAS chart carriage requirements

ENCs have the following attributes:

- ENC content is based on the latest source data available to the relevant Hydrographic Office;
- ENCs are compiled and encoded according to the international standards set by the IHO;
- Positions on ENCs are referred to the World Geodetic System 1984 Datum (WGS 84). This is directly compatible with GNSS positions;
- ENCs are issued only by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution; and
- ENCs are updated with official update information that is normally distributed digitally.



ENC data displayed on an ECDIS

How do I recognise an ENC?

When I am buying

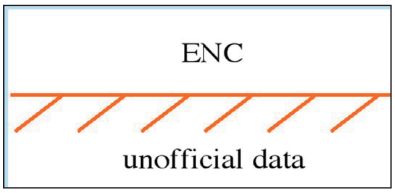
Only authorized user service providers and their distributors sell ENCs, generally under licence agreement; and the delivery of ENC Update information (the equivalent to the Notices to Mariners system for paper charts) is an essential part of their services. These user service providers are appointed either directly by the originating Hydrographic Office or by a Regional ENC Coordinating Centre (RENC) acting on behalf of its participating Hydrographic Offices.

Some national Hydrographic Offices distribute their ENCs directly to end-users. Where this occurs, ENCs (including Updates) must be downloaded from the Hydrographic Office's official website.

When used in an ECDIS

An ECDIS distinguishes ENC data from unofficial data. When unofficial data is used, ECDIS provides mariners with a continuous warning on the screen that they must navigate by means of an official, up to date ENC, RNC or paper chart.

If unofficial data is displayed on ECDIS, its boundaries are identified by a special line style - a "one-sided" RED line with the diagonal stroke on the side of the line containing the unofficial data.



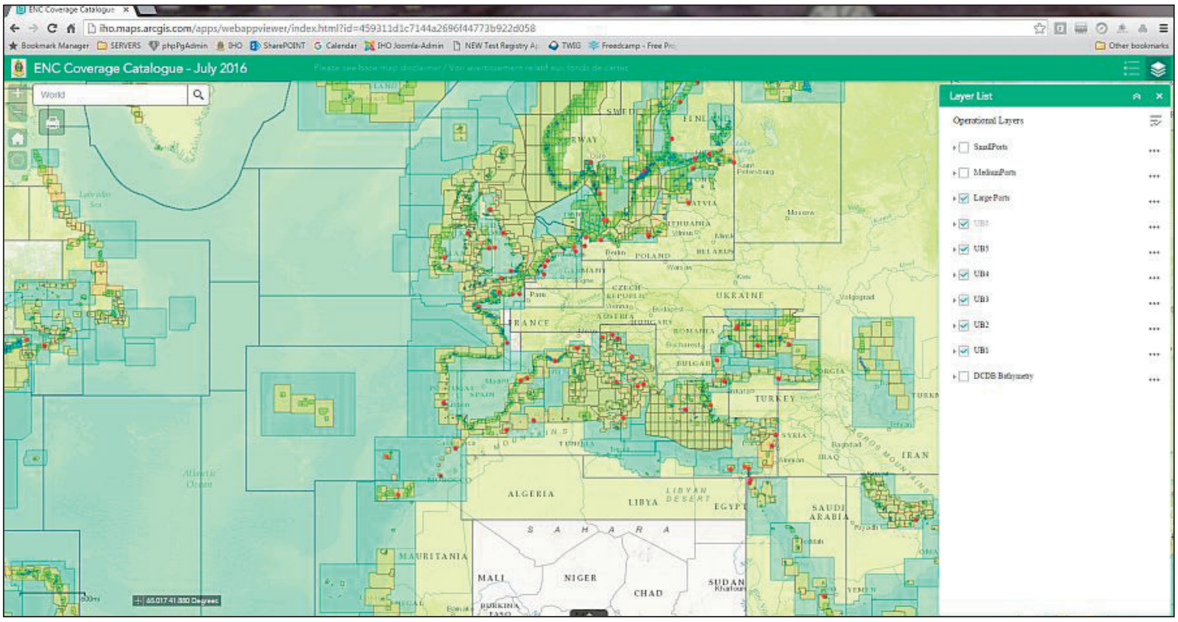
Boundary between ENC and unofficial data

The mariner can also select the appropriate ECDIS function that interrogates the chart display to obtain the chart details, such as information on the data originator, edition number and status of updating.

What ENCs are available?

In addition to RENC and national on-line catalogues, the International Hydrographic Organization (IHO) provides an interactive ENC Coverage Catalogue at *www.iho.int* > *ENCs & ECDIS* > *ENC Availability* that shows the availability status of ENCs worldwide.

The illustration below shows the front page of the catalogue:



IHO online catalogue for coverage and availability of ENC

How are ENCs protected from Unauthorised Changes?

The majority of ENCs are made available to the end-users in a protected form using the IHO S-63 ENC data protection scheme. S-63 protection ensures the integrity of the ENC data in all transactions between the service provider and the end-user. The protection scheme enables an ECDIS to confirm the authenticity of the supplied information.

S-63 defines the mechanism for encrypting ENC information and applying a digital signature to enable authentication of the chart data by an ECDIS. ECDIS users require an individual decryption key to access and view the ENC data protected by the S-63 scheme. Each ENC cell is encrypted with a different key. The decryption keys are provided to the end-user as ‘Cell Permits’ by ENC service providers. Decryption keys are unique and apply to specific end-user systems. As a consequence, they cannot be exchanged or shared between different ECDIS installations.

The operation of the ENC protection scheme should not add any operational overhead for ECDIS users. All aspects of ENC decryption and authentication should be handled automatically by the chart system. An ECDIS user will occasionally receive new Cell Permits from their service provider when their ENC subscription is renewed or there are changes to the ENC chart outfit. The updated Cell Permits must be imported into the ECDIS to enable it to automatically process new ENC deliveries and updates.

A few national Hydrographic Offices distribute their ENCs without using encryption. All ECDIS are able to access and display these unencrypted ENCs.

Are there other ways that ENCs can be distributed?

As well as distributing ENCs in the IHO S-57 format, the IHO has approved the distribution of ENCs in the internal “machine-formats” of individual ECDIS manufacturers. The generic name for this form of distribution is SENC distribution (System-ENC distribution). SENC distribution can improve the speed of loading ENC-data in some ECDIS equipment. The IHO requirements are that service providers offering SENC-distribution must have the agreement of the producer Hydrographic Office of the ENCs, and must also use type approved processes to ensure that the integrity of the S-57 format ENC data is maintained during the conversion to a SENC format.

What is an RNC?

RNC means “Raster Navigational Chart”. RNCs are digital raster copies of official paper charts. RNCs conform to IHO Product Specification S-61. In accordance with the SOLAS V definition of a nautical chart, RNCs can only be issued *by, or on the authority of, a Government, authorized Hydrographic Office or other relevant government institution*.

RNCs have the following attributes:

- RNCs are a facsimile of official paper charts;
- RNCs are produced according to the international standards set by the IHO;
- RNCs are regularly updated with official update information. This is distributed digitally.

The IMO ECDIS Performance Standard states that where ENCs are not available, RNCs may be used in ECDIS to meet the chart carriage requirements. However, when an ECDIS is being used with RNCs, the RNCs should be used together with “*an appropriate folio of up to date paper charts*”. See section “Meeting carriage requirements with ECDIS”.

The option to use RNCs in ECDIS will steadily reduce as more and more ENCs become available.

RNCs, when used in ECDIS do not provide the same level of functionality that is provided by ENCs. The limitations of operating with RNCs are outlined in Appendix 2 of IMO MSC.1/Circ.1503 (as amended) *ECDIS – Guidance for Good Practice*. Guidance on chart datum’s and the accuracy of positions is provided in IMO SN.1/Circ 255.

How are ENCs and RNCs kept up to date?

In order to meet the requirements of SOLAS V/27, nautical charts must be kept up to date by incorporating Notices to Mariners and other chart updates issued by Hydrographic Offices. (See Stage 9 in IHO S-65 - *ENCs: Production, Maintenance and Distribution Guidance*).

ENCs and RNCs are normally kept up to date by applying regular update information to the chart data via a digital data file. The update file may be transferred by wireless transmission, or on a suitable media, such as a CD-ROM. In these cases the updating of the chart database is done automatically by the ECDIS. Another standard function of ECDIS is the capability to update the ENC manually. This may be required when a digital update is not available or a hydrographic office has issued update information in a non-digital form.

ENC and RNC updates are generally supplied to ships on CD-ROM but 'remote updating' using satellite (or, when in port, shore based) telecommunications is becoming more and more common. Most ENC service providers now also provide updating services using e-mail, the worldwide web and other remote means. Details may be obtained from ENC distributors.

Is it possible to check that all updates have been applied to an ENC?

Updates to ENCs are sequential. The sequence is unique to each ENC. During the updating process ECDIS always checks that all updates in the sequence have been applied. If an update is missing then the ECDIS will indicate this. It is not possible to load later updates until any earlier updates have been applied.

An ECDIS maintains an internal list of the updates that have been applied and the date of their application. The format and content of an "ENC Update Status Report" is specified in Annex C of IHO standard S-63 "*IHO Data Protection Scheme*". Such a status report is designed to demonstrate the revision status of ENCs within the ECDIS SENC, and can be generated by the ECDIS user. Some ENC service providers (for example RENCs) also provide additional tools to generate reports on the "up-to-datedness" of the ENCs in the SENC. If ECDIS is not able to generate such a report, ECDIS users should create and maintain a list of updates manually. ENC distributors should be able to provide mariners with details of the latest ENC edition and update numbers in force. It is also possible to refer to traditional sources of update information, such as Notices to Mariners for paper charts, to cross-check and verify that corresponding ENC updates have been applied.

Port State Control officers are likely to refer to the update status report function of ECDIS to verify that ENCs are being kept up to date in accordance with SOLAS V Regulation 27.

A closer look at ECDIS

ECDIS equipment is specified in the IMO ECDIS Performance Standards (IMO Resolution MSC.232 (82) as follows:

Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention, as amended, 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.

ECDIS is a ship borne navigational device and as such the rules governing its use come under the jurisdiction of the IMO through SOLAS. The IMO has adopted performance standards for ECDIS (IMO Resolution MSC.232 (82) and subsequent amendments). ECDIS equipment must be certified as meeting these performance standards if it is to be used to meet the chart carriage requirements of SOLAS V/19. Certification of ECDIS equipment is achieved through type-testing and certification.

Within an ECDIS, the ENC database contains chart information in the form of geographic objects represented by point, line and area shapes, carrying individual attributes. Appropriate mechanisms are built into the ECDIS to query the data, and then to use the information to perform various navigational and monitoring functions (such as, anti-grounding surveillance) and to generate a chart-like display.

The presentation of ENC data on a screen display is specified in IHO standard S-52 "*Specification for Chart Content and Display Aspects of ECDIS*". The style of presentation defined in S-52 is mandatory.

How is an ECDIS approved and by whom?

To meet SOLAS requirements an ECDIS must be certified to show it conforms to the IMO Performance Standard for ECDIS. This is achieved through the type approval and certification processes recognised by the relevant Flag State.

Type approval is normally conducted by recognized technical organizations or by marine classification societies approved by Flag States. However in some countries the maritime administration conducts type approval themselves. Many European governments have agreed to mutual recognition of their ECDIS type approval certificates – indicated by the so-called "Wheel Mark" sign which indicates conformity with the Maritime Equipment Directive of the European Union (MED).

ECDIS type approval testing is conducted using test standards and procedures developed by the International Electro-technical Commission (IEC). These are based on the IMO Performance Standard for ECDIS and the supporting IHO standards (IHO S-52, S-57, S-63, S-64). The S-64 "*IHO Test Data Sets for ECDIS*" is used for type approval testing (not for mariners), and the IEC testing standard for ECDIS is IEC 61174 *(See: www.iho.int > ENCs & ECDIS > Information on IHO Standards related to ENC and ECDIS)*.

Is there a need to keep ECDIS software updated?

If ECDIS software is not upgraded to read ENCs based on the latest version of the S-57 ENC Product Specification or to use the latest version of the S-52 Presentation Library then the ECDIS may be unable to correctly display the latest approved chart symbols. If an ECDIS is unable to interpret and draw any newly introduced chart symbol it will display a question mark (?) instead. Additionally there will be a possibility that alarms and indications for any newly introduced features may not be activated even though they have been included in the ENC. Because of this, the IMO have issued guidance on the maintenance of ECDIS software in IMO MSC.1/Circ.1503 (as amended) *ECDIS – Guidance for Good Practice*.

ECDIS users should ensure that their ECDIS software always conforms to the latest IHO standards. This should be available from the "*about*" function in the software or from the ECDIS manufacturer. A list of the current IHO standards relevant to ECDIS software is maintained in the ENC/ECDIS section of the IHO website *(See www.iho.int > ENCs & ECDIS > Current ENC and ECDIS Standards)*.

Is there a mandatory requirement to carry ECDIS?

In July 2002 an amendment to Chapter V of SOLAS came into force. This amendment included a specific reference to ECDIS and stated that it

… may be used to fulfil the chart carriage requirements of Regulation 19.

A further amendment to Regulation 19 adopted in June 2009 requires that certain classes of vessel use ECDIS to meet the SOLAS V chart carriage requirements as follows:

Ship type	Size	New ships	Existing ships
Passenger ships	>= 500 GT	constructed on or after 1 July 2012	constructed before 1 July 2012: not later than the first survey* on or after 1 July 2014
Tankers	>= 3000 GT	constructed on or after 1 July 2012	constructed before 1 July 2012: not later than the first survey* on or after 1 July 2015
Cargo ships, other than tankers	>= 10 000 GT	constructed on or after 1 July 2013	see below
	>= 3000 < 10 000 GT	constructed on or after 1 July 2014	-
	>= 50 000 GT	-	constructed before 1 July 2013: not later than the first survey* on or after 1 July 2016
	>= 20 000 < 50 000 GT	-	constructed before 1 July 2013: not later than the first survey* on or after 1 July 2017
	>= 10 000 < 20 000 GT	-	constructed before 1 July 2013: not later than the first survey* on or after 1 July 2018
*Refer to the Unified interpretation of the term "first survey" referred to in SOLAS regulations (MSC.1/Circ.1290).			

Flag State authorities may exempt ships from the requirements shown above if those ships will be taken permanently out of service within two years after the implementation dates shown for other ships of the same class.

In addition to SOLAS V/19, ECDIS has already been fixed as the chart carriage requirement in the High Speed Craft Code of IMO (HSC). In December 2006 the 82nd session of the Marine Safety Committee (MSC82) agreed amendments to 1994 and 2000 HSC Code with regard to ECDIS:

… High-speed craft shall be fitted with an ECDIS as follows:

New vessels	Existing vessels
craft constructed on or after 1 July 2008	craft constructed before 1 July 2008, not later than 1 July 2010.

Meeting Carriage Requirements with ECDIS

Only a type-approved ECDIS operating with up to date ENCs and with appropriate back-up arrangements may be used to replace paper chart navigation. Where ENCs are not available, the SOLAS regulations allow Flag States to authorise the use of RNCs (together with an appropriate folio of paper charts) - see below. In all other cases the vessel must carry all the paper charts necessary for its intended voyage.

Back-up Requirements

No electronic system can be completely failsafe. The IMO Performance Standard for ECDIS therefore requires that the "overall system" includes both a primary ECDIS and an adequate, independent back-up arrangement that provides:

- *Independent facilities enabling a safe take over of the ECDIS functions in order to ensure that a system failure does not result in a critical situation*; and
- *A means to provide for safe navigation for the remaining part of the voyage in case of ECDIS failure.*

However, these rather basic statements allow for considerable flexibility. This means that there can be various interpretations as to what are the minimum functional requirements, or what constitutes "adequate" back-up arrangements.

There are two commonly accepted options:

- A second ECDIS, connected to an independent power supply and a separate GNSS position input;
- Up to date paper nautical charts sufficient for the intended voyage

Some Flag States may, however, permit other options (for example: radar-based systems such as "Chart-Radar"). Ship owners should consult their national maritime administration for specific guidance.

At the request of the IMO, the IHO has sought information from its member states on which paper charts covering their territorial waters would be considered as *appropriate* to serve as a back-up to ECDIS. This information is presented on the IHO web site as part of the ENC coverage catalogue *(See www.iho.int > ENCs & ECDIS > ENC Availability > Backup Paper Charts).*

What to do in areas without ENC coverage?

In 1998 the IMO recognised that it would take some years to complete global coverage of ENCs. As a consequence, the IMO ECDIS Performance Standard was amended by adding a new optional mode of operation for ECDIS - the Raster Chart Display System (RCDS) mode. In this mode Raster Navigational Charts (RNCs) can be used in ECDIS to meet the SOLAS carriage requirements for nautical charts. However, this is only allowed if approved by the Flag State of the ship concerned. The intention of the change was to provide the widest possible coverage of official electronic chart data for ECDIS in advance of complete global coverage with ENCs alone.

IMO took note of the limitations of RNCs as compared to ENCs (see Section D "*Differences Between Raster Chart Display (RDCS) and ECDIS*" of IMO MSC.1/Circ.1503 (as amended)). As a consequence, the revised ECDIS Performance Standard requires that when the RCDS mode is employed an ECDIS must be used together with "*an appropriate folio of up to date paper charts*".

The following definition of *an appropriate folio of up to date paper charts* (APC) was established by MSC within appendix 7 of Resolution MSC.232(82):

Appropriate Portfolio of up to date paper Charts (APC) means a suite of paper charts of a scale to show sufficient detail of topography, depths, navigational hazards, aids to navigation, charted routes, and routeing measures to provide the mariner with information on the overall navigational environment. The APC should provide adequate look-ahead capability. Coastal States will provide details of the charts which meet the requirement of this portfolio, and these details are included in a worldwide database maintained by the IHO. Consideration should be given to the details contained in this database when determining the content of the APC.

While paper charts are to be used with RNCs, the underlying intention was, nevertheless, to minimise the number of paper charts carried by a vessel when the RCDS mode was employed, but only to a level compatible with safe navigation. As stated by the IMO, ship owners should consult their Flag State regarding whether RCDS mode is allowed and under what conditions.

A web-based catalogue showing world coverage of all ENCs and RNCs is available on the IHO website *(http://www.iho.int > ENCs & ECDIS > ENC Availability).*

In any areas where both ENCs and RNCs are unavailable vessels must carry all the paper charts necessary for the intended voyage.

Does your ECDIS system meet IMO chart carriage requirements?

ECDIS Carriage Requirements – a summary:

Are ENCs available for area of operation?	**YES**	**NO**	**YES**	**NO**
What Digital Charts are being used in the ECDIS by the mariner?	ENC (coverage at an appropriate scale for navigation)	RNC (coverage at an appropriate scale for navigation)	RNC	Private charts (6)
What back-up system is required?	Independent ECDIS or other back-up solution required	Independent ECDIS or other back-up solution required	None required (3)	None required (3)
What are the requirements for the carriage of Official paper charts?	None needed (1) (except if back-up is a folio of paper charts)	An “appropriate” folio of up to date paper charts to be used in conjunction with the ECDIS in RCDS mode	All up to date paper charts required for safe navigation in areas where ENCs are available	All up to date paper charts required for safe navigation for the intended voyage
How is the ECDIS operating?	As an ECDIS	As an ECDIS in RCDS mode	As an ECDIS in RCDS mode	As an ECS
Does the ECDIS fulfil Chart Carriage Requirements?	YES (1)	YES (2)	NO (4)	NO(5)

Notes:

1. Some Flag States may require specific documentation to allow this.
2. Requires approval of vessel’s Flag State – Flag State defines meaning of ‘appropriate’.
3. Back-up system is only required if ECDIS is intended to meet carriage requirements.
4. For ECDIS to fulfil Carriage requirements vessels must use ENCs where these are available.
5. Paper charts (not the ECDIS) must remain the primary means of navigation.
6. If private charts are used in an ECDIS the system is regarded as operating as an ECS. ECDIS operating as ECS; ECS systems meeting RTCM or IEC standards; or Private charts meeting ISO standards being used in ECDIS, do not meet IMO chart carriage requirements.

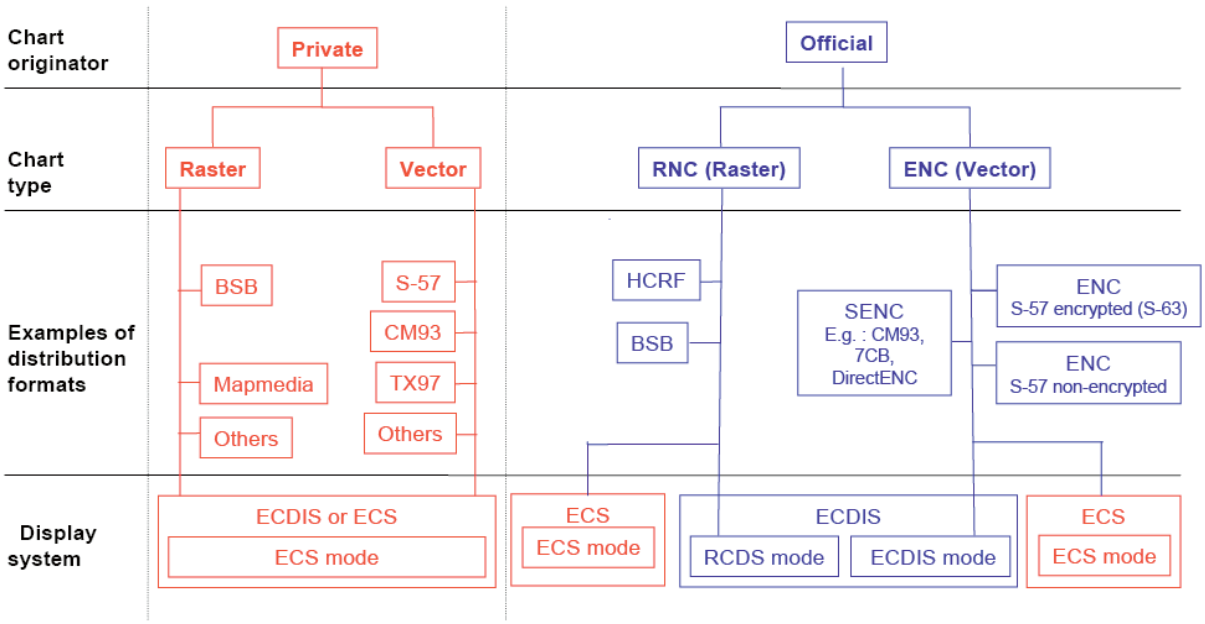
It should be noted that interpretations between Flag State administrations may vary. Additionally in some countries Flag State administrations will require to check the equipment on board before issuing any certificates. Prospective ECDIS users should consult the vessel’s Flag State administration for detailed information.

Can chart format names indicate carriage compliance?

There has been much confusion regarding the names used to describe electronic chart distribution formats. The diagram below is intended to clarify this. From the diagram it can be seen that the same distribution format can be used for the delivery of both "private" (not produced officially by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution) and official chart data. For example, 'BSB' is the term used for the distribution format of US and Canadian RNCs. The same term is also used for the distribution of private raster chart data in other areas (for example, in European waters).

There can also be confusion with ENCs and End-User Service Providers packages. Private vector chart data delivered in S-57 format does not meet IMO requirements and should never be described as an ENC. Similarly private vector data delivered in a SENC format can be mistaken as being ENCs delivered in the same SENC format.

The most important factor to consider in determining whether data is official is the electronic chart producer rather than the format. The electronic chart producing authority determines the status and the purpose for which the chart data may be used. The combination of the status of the chart data and the functionality of the particular device finally determines whether an electronic chart navigation "system" is operating as an ECDIS or as an ECS.



Examples of Electronic Chart Formats. Many ECS systems are able to use ENC or RNC data, however even when using official charts they may not be used to fulfil ECDIS carriage requirements in accordance with SOLAS chapter V

Examples of format names used by private data producers:

- CM93 chart data produced by C-Map.
- TX90 vector chart data produced by Transas.

Acceptance of ECDIS by Port State Control Authorities

Ships arriving at a port are normally subject to Port State control. This is enforced by local officials (Port State Control Officers (PSCO's)) who refer to the relevant Flag State regulations and international agreements. Nations have formed a number of regional groups to ensure consistent application of Port State control.

In Europe, Port State control follows the guidance set out in the "*Guidelines for Port State Control on Electronic Charts (Paris Memorandum of Understanding)*". Its ECDIS guidelines explain how a PSCO should assess whether a ship is using electronic charts in accordance with SOLAS requirements. Checks may include whether:

- The ship has documentation indicating that the ECDIS complies with the IMO ECDIS Performance Standards. In the absence of such documentation, the PSCO should seek confirmation from the Flag State that the ECDIS does meet the statutory requirements;
- The ECDIS is being used for primary navigation. It should be established if the ECDIS is used in ECDIS mode or RCDS mode or in both modes;
- There are written procedures onboard the vessel for using ECDIS;
- The master and watch-keeping officers are able to produce appropriate documentation that basic ECDIS familiarization has been completed and demonstrate familiarization with the ECDIS equipment installed on board;
- The ENCs (and any RNCs) used for the intended voyage are up to date; and
- There are approved back-up arrangements available to ensure a safe transfer of the ECDIS functions in the event of an ECDIS failure and to provide safe navigation for the remaining part of the voyage.

Is there a need for ECDIS training?

ECDIS is far more than the image of a chart displayed on an electronic screen. ECDIS is a highly sophisticated system which, besides the navigational functions, includes components of a complex, computer-based information system. In total, the system includes hardware, operating system, ECDIS software (kernel and user interface), sensor input interfacing, electronic chart data, rules for presentation and display, status and parameters of alarms and indications, etc. All these items are accessed through an appropriate human-machine interface. As such, care must be taken when navigating with ECDIS to avoid:

- Incorrect operation;
- Misinterpretation;
- Malfunction; or, even worse,
- Over-reliance on this highly-automated navigation system.

With any type of shipboard navigation equipment, it can only be as good as those who use it and what it is being used for. In the case of ECDIS and ENCs, if the mariner is well trained then the system will provide the relevant information that the mariner needs in order to make good decisions and thereby contributes significantly to safe and efficient navigation. Stated another way, an ECDIS is another tool to enable mariners to perform their job better. However, just having some “knowledge” about “functions” and “operational controls” is insufficient to maximise the benefits of ECDIS; proper training is absolutely necessary.

What are the requirements for ECDIS training?

ECDIS and other electronic charting systems have become increasingly important in ship navigation and are widely used either as a primary navigation tool or as an aid to navigation. The systems are complex, and require adequate and appropriate training in order to be operated correctly and safely. Without proper training, these systems will not be used to their full potential and could under some circumstances increase the hazard to navigation. The IMO STCW (Standards of Training, Certification and Watch-keeping) and ISM (International Safety Management) codes put the responsibility firmly on the ship-owner to ensure that mariners on their vessels are competent to carry out the duties that they are expected to perform. If a ship is fitted with ECDIS, the ship-owner has a duty to ensure that users of such a system are properly trained in its operation and use before using it operationally at sea.

On the 1st of January 2012, the "2010 Manila Amendments" to the STCW Convention entered into force. The amendments include binding minimum ECDIS standards for the training and advanced training of masters and navigating officers. They include:

- Basic training intended to convey a basic level of competency. This is mandatory for masters and navigating officers, and require certification for the corresponding levels of competence. (Chapter II of the Annex to the STCW Convention); and
- Type-Specific Training which should provide appropriate training on ship-specific ECDIS equipment. Companies are responsible for ensuring that seafarers employed on their ships are familiarized with the installed ECDIS, but seafarers are not required to provide documentation (certificates) of having completed this training. (Regulation I/14 of the Annex to the STCW Convention and IMO STCW.7 Circ.24 (as amended)).

The provisions were implemented gradually during an interim period until 1 January 2017, and are now in place.

To encourage effective ECDIS education, the IMO has approved a syllabus for a standardised model course for the general operation and use of ECDIS (IMO Model Course 1.27). In May 2012 (at the 43rd STCW meeting), the Model Course was revised and updated (annex to STW 43/3/1) in order to make provision for the generic use of ECDIS.

Courses based on this syllabus are offered by approved training institutions and maritime academies. Maritime administrations can provide information on approved institutions. Some Flag States have developed their own training courses in ECDIS in order to be able to recognise the training certificates.

Type-specific ECDIS training is normally available from the ECDIS equipment manufacturer.

Further information on ECDIS training can be found in Section 3 of this document.

What are the operational considerations when using ECDIS?

The IMO has recognised that the adoption of a carriage requirement for ECDIS from 2012 is a very significant change for the shipping industry and that there will need to be a careful transition both within the ship operating companies, and onboard the ships of their fleet. In 2008 the IMO issued a Safety of Navigation Circular (IMO SN/ Circ. 276) on "*Transitioning from paper chart to ECDIS navigation*", which has been superseded and is now included at Section F of IMO MSC.1/Circ.1503 (as amended) *ECDIS – Guidance for Good Practice*.

Navigating with ECDIS is fundamentally different from navigating with paper charts. Important bridge work-processes are significantly affected, in particular, the voyage planning and voyage execution tasks. These differences require careful analysis and consideration.

Voyage Planning

ECDIS provides a number of additional planning functions and features such as the use of safety contours, various alarms and indications, and click-and-drop facilities for designating waypoints and markers. Whilst in many ways ECDIS makes voyage planning easier, it is still possible to make errors. However these errors are likely to be of a different type to those encountered when using paper charts.

Even though world-wide ENC coverage has almost been achieved, many vessels may, to some degree, have to operate a dual, or even triple, system with a voyage covered by various combinations of ENCs, paper and raster charts. The planning and validation of an intended voyage has therefore to consider issues such as which chart types are available for the various segments of that voyage. The format of the voyage plan is likely to differ from the traditional alphanumeric lists of waypoints used with paper charts and should include information on the usability of connected electronic navigational devices such as GPS and AIS and their actual alarm settings.

It is essential to make use of the in-built automatic checking functions provided by ECDIS when validating and approving the voyage plan. Thought also needs to be given to ensuring that a backup to the voyage plan on the ECDIS is available in case of equipment failure of the ECDIS or the connected sensors.

It is important that there is a good understanding of the voyage plan by all bridge officers so that they are prepared for the intended voyage. This should include information on equipment status and backup procedures.

Voyage execution

- At the beginning of a voyage, as well as at any change of watch, officers should review the voyage plan and agree the selected pre-settings of functions, alarms and indicators to be used on the ECDIS.
- Where vessels carry paper charts as well as an ECDIS, the role of the ECDIS and the paper charts should be considered. If the ECDIS is used for real time navigation, the statutory requirements regarding monitoring of the progress of the voyage and marking of positions will need to be considered:
    - Are positions marked on paper charts solely for record keeping purposes?
    - What steps are being taken to ensure that intended tracks marked on the paper charts correspond with the ECDIS information?
    - Have the bridge procedures set in place by the shipping company been adapted for the use of ECDIS and are all persons concerned with the navigation of the vessel familiar with these adjustments?

Over reliance on ECDIS

There is a tendency to put too much trust in computer-based systems and, in the case of ECDIS, to believe implicitly in whatever is shown on the chart display. It is essential that officers remember to cross check the displayed information by all means available; especially by visual observation and comparison from the bridge window and by watching the radar. Bridge-procedures must be adapted appropriately and ENC training must be carried out to minimise the potentially adverse consequences.

More on ECS

All electronic charting systems, which are not tested and certified as meeting the IMO ECDIS Performance Standards, are generically designated as “Electronic Chart Systems” (ECS). An ECS may be able to use ENCs, RNCs or other chart data produced privately and could have functionality similar to ECDIS.

Some ECDIS and ECS equipment manufacturers also produce private vector and raster data to use in their products. These private charts are usually derived from Hydrographic Office paper charts or Hydrographic Office digital data but these derived charts have no official status.

Hydrographic Offices do not take any responsibility for the accuracy or reliability of privately produced charts. Where a SOLAS vessel operates with ECS, the paper chart remains the only officially recognised basis for navigation onboard. In these circumstances a vessel must retain and use a full folio of up to date paper charts onboard, regardless of the type of electronic charts used.

Because ECS is not intended to meet SOLAS chart carriage requirements, there is no IMO Performance Standard for ECS.

The STCW and ISM codes place the responsibility firmly on the ship-owner to ensure that mariners on their vessels are competent to carry out the duties that they are expected to perform. If a ship has an ECS fitted for use and it is being used as an aid to navigation, the ship-owner has a duty to ensure that users of such a system are properly trained in its use before employing it operationally at sea, are aware of its limitations compared to ECDIS and the need to use paper charts to fulfil the SOLAS chart carriage requirements.

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SECTION 2: LIST OF FLAG STATE AUTHORITIES

Note: This list as of June 2017 is not exhaustive and is not kept up-to-date.

Nation	Website
Antigua & Barbuda	http://www.antiguamarine.com/
Australia	http://www.amsa.gov.au/
Bahamas	http://www.bahamasmaritime.com/
Barbados	http://www.barbadosmaritime.com/
Belgium	http://mobilit.belgium.be/en
Bermuda	www.bermudashipping.bm
Canada	http://www.tc.gc.ca/eng/marine-menu.htm
Cayman Islands	www.cishipping.com
China	http://en.msa.gov.cn/
Cyprus	http://www.shipping.gov.cy/
Denmark	http://www.dma.dk
Estonia	http://www.vta.ee/?lang=en
Finland	http://www.liikennevirasto.fi/web/en
France	http://www.ecologique-solidaire.gouv.fr
Germany	http://www.bsh.de/en/index.jsp
Gibraltar	http://www.gibmaritime.com/
Greece	http://www.hrs.gr/
Hong Kong (China)	http://www.mardep.gov.hk/en/pub_services/home.html
India	http://shipping.gov.in/
Ireland	http://www.transport.ie/
Isle of Man	http://www.gov.im
Italy	http://www.mit.gov.it/mit/site.php?p=cm&o=vd&f=cl&id_cat_org=34&id=218
Japan	http://www.mlit.go.jp/index_e.html
Korea, Republic	http://www.krs.co.kr/eng/main/main.aspx
Liberia	http://www.liscr.com/liscr/
Malaysia	http://www.marine.gov.my
Malta	http://www.transport.gov.mt/
Marshall Islands	http://www.register-iri.com/
Netherlands	https://www.ilent.nl/
New Zealand	http://www.maritimenz.govt.nz/default.asp
Norway	http://www.nis-nor.no/
Panama	http://www.segumar.com/
Philippines	http://www.prc.gov.ph
Poland	http://emsa.europa.eu/
Russian Federation	http://www.rs-head.spb.ru/en/index.php
Singapore	http://www.mpa.gov.sg/sites/utility_navigation/Contact_info.page
South Africa	http://www.samsa.org.za
St Kitts & Nevis	http://www.stkittsnevisregistry.net/
St Vincent & Grenadines	http://www.svg-marad.com/home.asp
Sweden	https://transportstyrelsen.se/en/shipping/
Thailand	http://www.mot.go.th/about.html?dsfm_lang=EN&id=7
United Kingdom	http://www.mcga.gov.uk
USA	http://www.marad.dot.gov/
Vanuatu	http://vanuatuships.com/content/view/107/43/
Vietnam	http://www.vr.org.vn/VRE/homeNE.aspx

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SECTION 3: ECDIS TRAINING

See also Appendix 3 of IMO MSC.1/Circ.1503 (as amended) ECDIS – Guidance for Good Practice.

Training Objectives

The overall objective of ECDIS training is to enhance navigation safety. In rather general terms, this includes

- Safe operation of the ECDIS equipment
  - Use of the functions for route planning and monitoring
  - Proper action in case of any malfunction
- Proper use of ECDIS-related information
  - Selection, display, and interpretation of relevant information
  - Ambiguities of data management (such as “datum”)
  - Assessment of ENC data quality indicators (for example CATZOC)
  - Assessment of alarms and indications
- Awareness of ECDIS-related limitations
  - Errors of displayed data and their interpretation
  - Real and potential limitations
  - Over-reliance on ECDIS
- Knowledge of legal aspects and responsibilities related to electronic charts
  - Awareness of the status of ECDIS and ECS; of official and non-official data
  - Limitations of RCDS mode

In order to achieve these objectives, the mariner must acquire a thorough knowledge and functional understanding of the basic principles governing ENC data, its proper display in ECDIS and its use with navigation sensors and their respective limits. For example, the Mariner must be familiar with the object-attribute structure and the feature-space relationship of ENC data as well as charted information; and the impact of such things as “SCAMIN”, “overscale”, “update history”, “CATZOC”, “safety values” and “chart usage”.

ECDIS training must have an appropriate depth in theoretical aspects (ECDIS data and their presentation) as well as dealing with the proper use of ECDIS (functions and limitations). It should cover all safety-relevant aspects and go far beyond type-specific “button pressing” or basic operations. ECDIS training should be both generic and type-specific.

Ideally, training should cover the full extent of functions and procedures necessary to deal with a wide range of possible navigational problems. It should cover thorough route planning and both visual and automatic route monitoring in typical navigational situations and sea areas. To prepare a user for practical operations, decision-making and alarm handling, real-time complex ECDIS simulator exercises should be conducted.

IMO Model Training Course - *Operational Use of ECDIS*

The IMO Committee on Standards for Training and Watch-keeping (STW) approved a standardised IMO "Model Training Course on the Operational Use of ECDIS" (Model Course 1.27). The primary objective of the Model Course is to ensure proper use and operation of ECDIS in terms of a thorough understanding and appreciation of its capabilities and limitations. The IMO Model Course contains four main parts:

- Part A: Course framework;
- Part B: Course outline and time table;
- Part C: Detailed teaching syllabus;
- Part D: Instructor manual; and
- Part E: Evaluation and assessment.

There are also annexes dealing with proposals and examples of situations for the development of scenarios and of "errors of interpretation".

In May 2012 (at the 43rd Standards of Training, Certification and Watch-keeping (STCW) meeting), the Model Course was revised and updated (annex to STW 43/3/1) in order to make provision for the generic use of ECDIS in addition to type-specific ("familiarization") training.

The contents (syllabus) of ECDIS training are listed below. They are based on the analysis of onboard navigational activities and include learning objectives at the operational as well as the management level (for example STCW Convention). In addition to providing specific learning objectives and detailed guidance on a range of subject areas, the Model Course also contains recommendations for facility and staffing requirements, entry standards, lesson plans, teaching aids, examples of ship-simulator training exercises that can be conducted, and certificates.

- Legal aspects and requirements
- Main types of electronic charts and their differences
- ECDIS data
- Presentation of data
- Sensors
- Basic navigational functions
- Special functions for route planning
- Special functions for route monitoring
- Updating
- Additional navigational functions and indications
- Errors in displayed data
- Errors of interpretation
- Status information, warnings and alarms
- Voyage documentation
- System integrity monitoring
- ECDIS back-up
- Risks of over-reliance on ECDIS

The IMO Model Course 1.27 - *The Operational Use of Electronic Chart Display and Information System (ECDIS)* together with its annex and attachment is regarded as the minimum requirements a candidate should have gone through to receive an ECDIS certificate. It covers all relevant safety aspects and overall system knowledge. Governments are strongly recommended to ensure that every officer in charge of a navigational watch is trained and certified in accordance with the objectives of the course.

Certification of ECDIS Education

The certificate should document that:

- The candidate has completed a course in the operational use of ECDIS (Electronic Chart Display and Information Systems), based upon the IMO Model Course 1.27 - *The Operational Use of Electronic chart Display and Information systems (ECDIS)*.
- The course fulfils the requirements of IMO STCW-95.

The certificate should be issued by a government authority or a relevant body that is government approved.

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SECTION 4: TECHNICAL DETAILS OF ELECTRONIC CHARTS

Official Electronic Chart Data

The term "Official", indicates chart data that has been produced under the authority of a government organization – in contrast to private, or non-official, electronic chart data which might be technically of the same type but has not been endorsed by a government authority. By definition, the terms ENC(s) and RNC(s) only refer to officially endorsed electronic charts.

Types of Official Chart Data

Electronic chart data is of two general types:

- Electronic Navigational Charts (ENC), and
- Raster Navigational Charts (RNC).

The inner construction of ENCs and RNCs is fundamentally different:

- ENCs are *vector* charts, and
- RNCs are *raster* charts.

Electronic Navigational Charts (ENCs)

General Principles

IMO's definition for the Electronic Navigational Chart – ENC:

Electronic Navigational Chart (ENC) means the database, standardized as to content, structure and format, issued for use with ECDIS by or on the authority of a Government, authorized Hydrographic Office or other relevant government institution, and conform to IHO standards. The ENC contains all the chart information useful for safe navigation and may contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions), which may be considered necessary for safe navigation.

ENCs are vector charts comprising a database of individual geo-referenced objects extracted from a Hydrographic Office's records including existing paper charts. When used in an ECDIS, the ENCs content can be displayed as a seamless chart-like display at user selected scales. Due to the limited size and resolution of electronic displays the chart image generated from ENCs may not fully replicate the traditional appearance of a paper chart. This apparent shortcoming is more than compensated for by the special operational functions of ECDIS which continuously monitors the ENC data content (rather than the display) to provide warnings of impending dangers in relation to a vessel's position and its movement.

ENC Data Format

ENCs are formatted in accordance with the latest version of ENC Product Specifications as published by the IHO *(See www.iho.int > ENCs & ECDIS > Current ENC and ECDIS Standards)*. These Product Specifications describe the standards to be used for the exchange of digital hydrographic data between national Hydrographic Offices and for the distribution of digital data and products to manufacturers, mariners, and other data users. The current ENC Product Specification is based on the IHO S-57 data format which is the IHO Transfer Standard for Digital Hydrographic Data. The current version of S-57 is Edition 3.1. A new ENC Product Specification S-101 is currently (2017) under development, based on the IHO S-100 Universal Hydrographic Data Model.

ENCs use the World Geodetic System 1984 (WGS 84) as the horizontal datum reference. This makes most ENCs directly compatible with GNSS. However, a few ENCs have been compiled from older non-WGS 84 paper charts and a close match with GNSS positions cannot be assured. These ENCs carry an extra warning that will be displayed in the ECDIS, such as "This chart cannot be accurately referenced to WGS 84 Datum; see caution message". A typical caution message would be: "Positions in this region lie within ± nn metres of WGS 84 Datum".

See also IMO SN.1/Circ.213 ***Guidance on Chart Datums and the Accuracy of Positions on Charts***; and IMO SN.1/Circ.255 ***Additional Guidance on Chart Datums and the Accuracy of Positions on Charts*** for additional information on horizontal datum reference.

ENC Display

An ENC is a database of geographic entities. It currently does not contain any presentation rules.

Both the geo-referenced data objects contained in the ENC and the appropriate symbolisation contained in the S-52 ECDIS Presentation Library are linked to each other in the ECDIS only when called up for display. The resulting image will change depending on the sea area selected, the intended display scale and the mariner's pre-settings, such as the display mode best suited to the ambient light conditions, and other operational conditions.

The presentation rules for ENCs are contained in a separate ECDIS software module - the "Presentation Library". The definition of the Presentation Library for ENCs is contained in Annex A of the IHO Publication S-52 – *Specifications for Chart Content and Display Aspects of ECDIS*. The use of the S-52 symbology and presentation rules is mandatory in all ECDIS.

The ECDIS Presentation Library follows, as much as possible the presentation and symbology used on a paper chart. This will avoid confusion during the extended period when paper charts, RNCs and ENCs will co-exist. However, the ECDIS display provides a much increased level of flexibility compared to a paper chart. This includes:

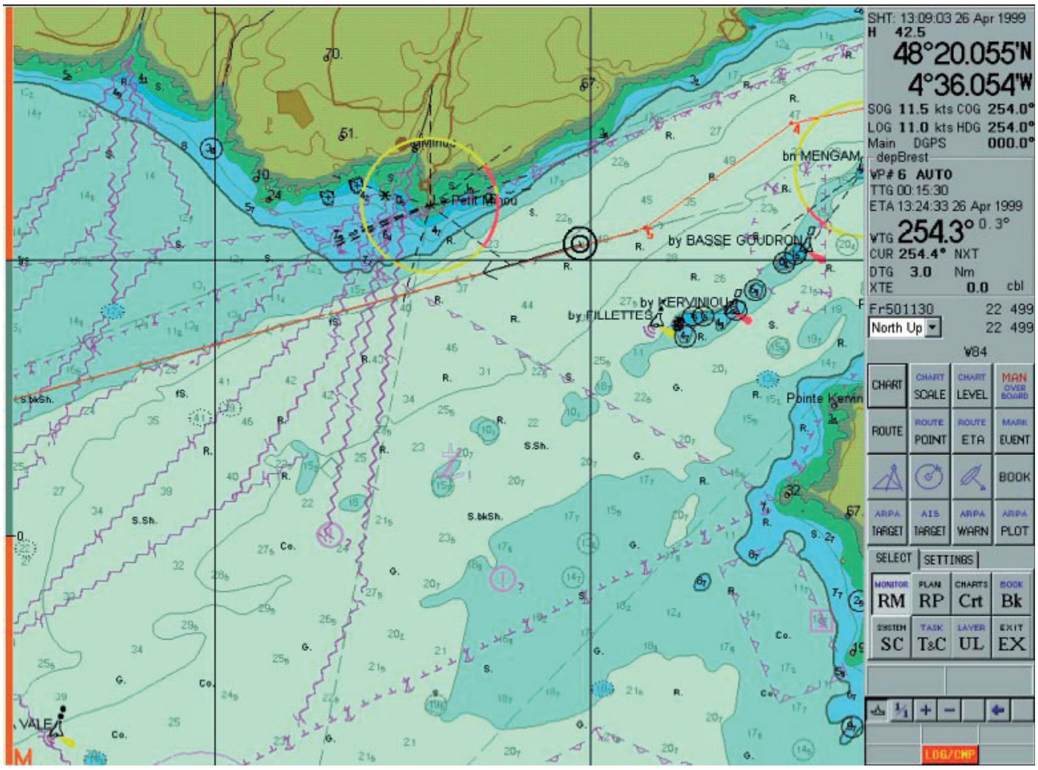
- Displaying/removing various types of chart and non-chart information;
- Selecting standard chart display or a thinned out display, and full or simplified symbols;
- Using cursor interrogation to obtain further detail not shown on the continuous display;
- Overlaying/removing radar video or radar target information (in order to: confirm ship's positioning; aid radar interpretation; show the entire navigation situation on one screen);
- Overlaying/removing various other sensor information, or information transmitted from shore;
- Changing the scale or orientation of the display;
- Selecting true motion or relative motion;
- Changing screen layout with windowed displays, providing text 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;
- Giving 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;
- Possibly, a diagrammatic representation of the immediate vicinity of the ship to aid in close quarters manoeuvring;

The ambient lighting on the bridge varies between the extremes of bright sunlight, which can wash out information on the ECDIS display, and night, when the light emitted by the display has to be low enough that it does not affect the mariner's night vision. The colours and symbols specifications of S-52 have been designed to meet these more difficult requirements. ECDIS provides a negative image of the chart at night, using a dark background in place of the white background of the paper chart, in order not to impair night vision.

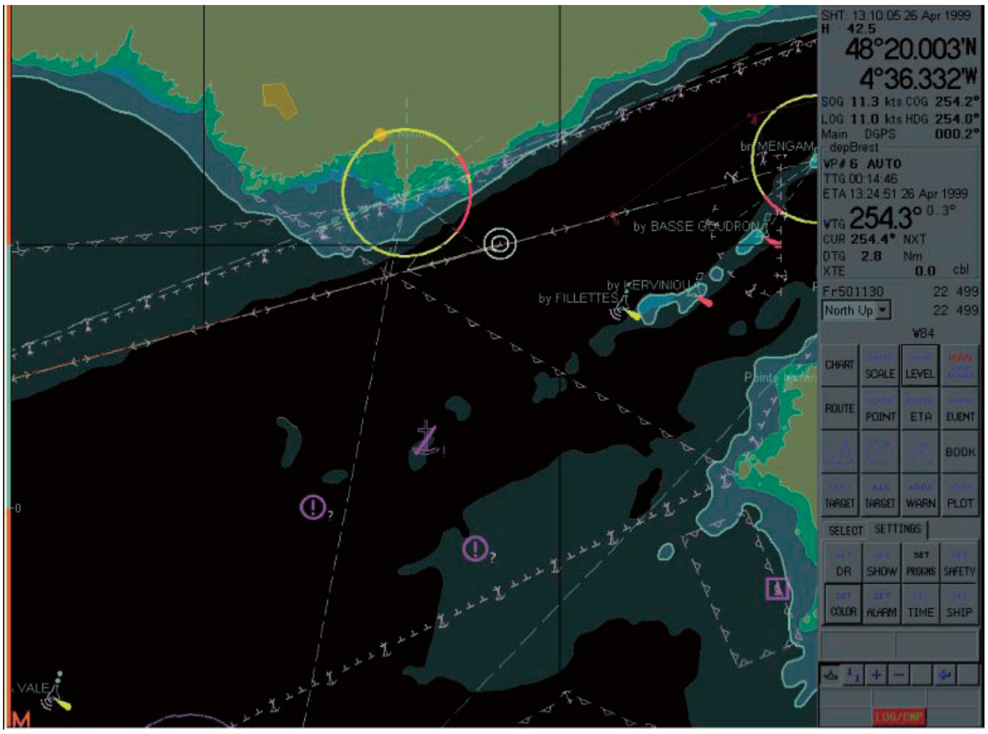
Three predefined colour schemes are provided:

- Day (white background)
- Dusk (black background)
- Night (black background)

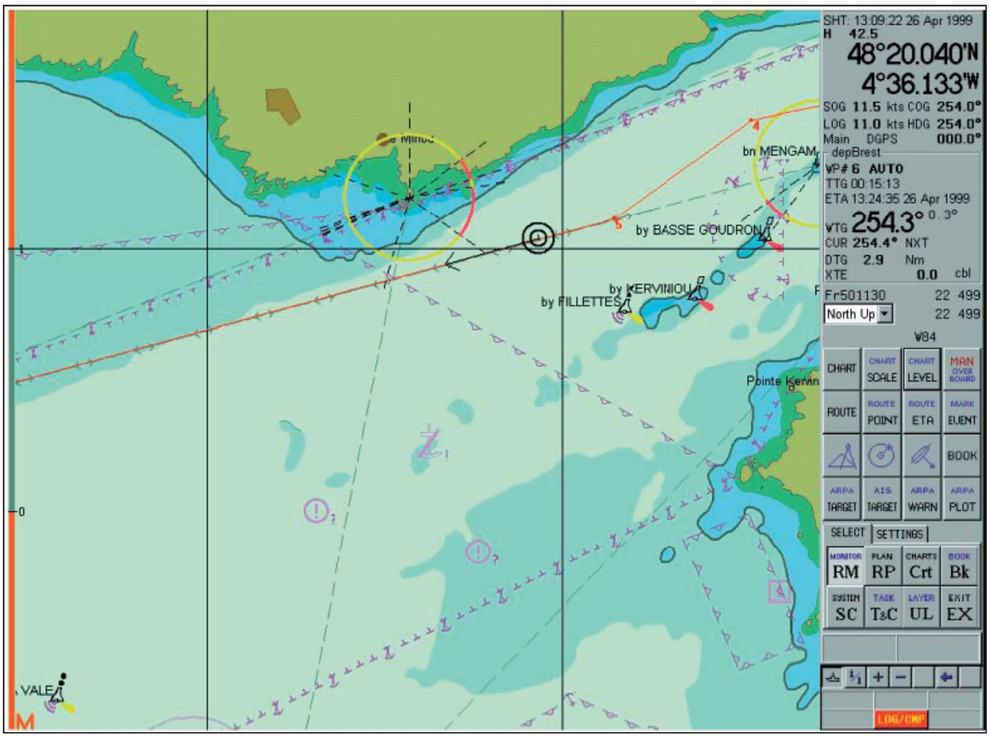
The following illustrations show two of the colour schemes and the three standard selections of content; that is Standard Display, Base Display and Full Display.



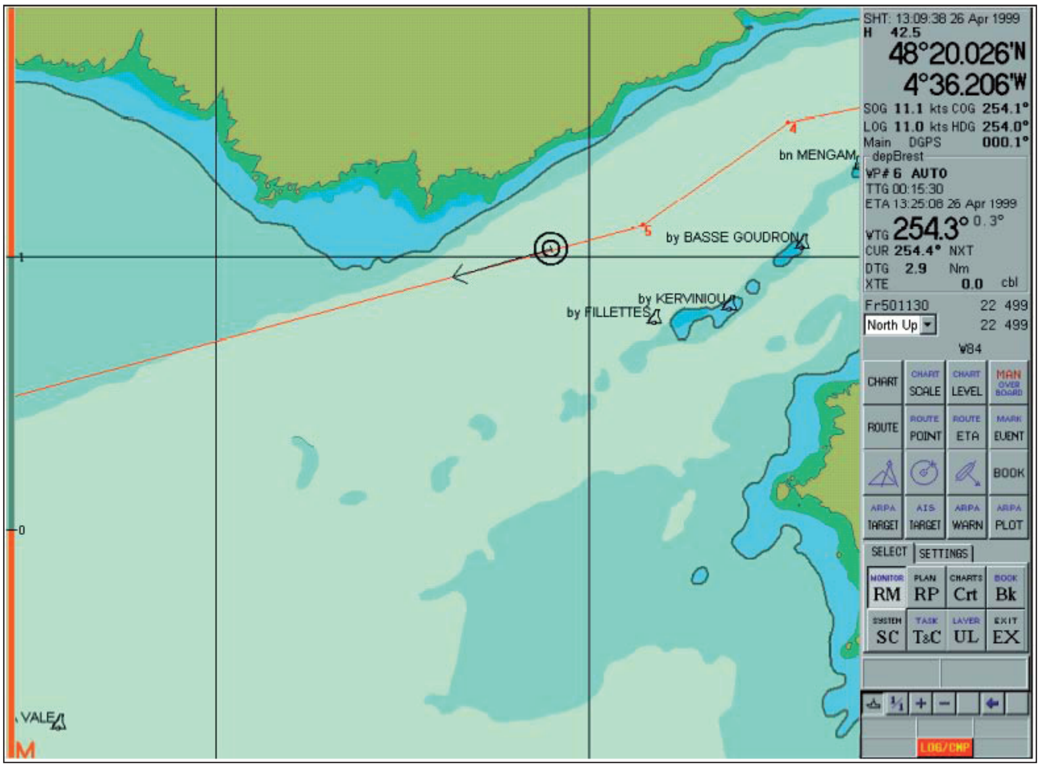
Standard Display, day



Standard Display, night



Base Display, day



Full Display, day

INFORMATION ON ENC GENERALIZATION, OVER-SCALING AND SAFETY CHECKING FUNCTIONS IN ECDIS.

Executive summary

This information paper focuses on the importance of understanding ENC compilation scale and the safety implications of using ENC data beyond its intended usage, during both the Electronic Chart Display and Information Systems (ECDIS) route planning and checking and route monitoring phases of navigation.

The paper provides ECDIS users with information regarding the process Hydrographic Offices employ to transform the physical world into a 2D Electronic Navigational Chart (ENC) that can be used in an ECDIS. Within the paper the following topics are covered:

Cartographic generalization practices

For centuries marine cartographers have been using generalization techniques to transform our view of the world from a true three-dimensional reality to a scaled, two-dimensional abstract view. Many aspects to generalization are used by Hydrographic Offices when creating navigational products: classification, simplification, exaggeration, and symbolization.

Classification: Groups features into classes having identical or similar attributes. Organizing features into fewer classes helps to simplify and clarify the message of the navigational chart.

Simplification: Features are simplified by either smoothing or compacting. Smoothing is generally used for linear features such as depth contours and coastlines where each curve cannot be depicted because of scale or because the detail would clutter the chart.

IHO Chart Specification S-4 states *'Contours should be smoothed only where it is necessary to remove intricacies which would confuse mariners. Where necessary, smoothing will include deeper water within shoaler contours (that is: it must be shoal-biased), but an attempt to retain a reasonable representation of the seabed should be made'.*

In compacting, if there are many features in a small area, such as isolated rocks which will just be dots at chart scale; those features may be grouped (compacted) within a single obstruction area.

Exaggeration: Due to scale, certain features must be shown larger than their actual relative size. Dangerous features such as rocks, wrecks and obstructions would at certain scales be unreadable if shown at their correct size, so they are exaggerated enough to be recognized and to show their relationship to other similar features.

Symbolization: Symbols are used on charts to inform the Mariner what features are. Nautical chart symbols use shape and colour to help the Mariner quickly understand the importance of certain features. For example, the colour magenta is generally reserved for drawing attention to symbols for features which have a significance extending beyond their immediate location; or are not themselves a physical feature (such as administrative and restricted areas; or routeing measures).

Globally accepted cartographic practices include the use of point symbols to represent real-world area features when the scale of the product is reduced but the importance of the feature is such that the cartographer wants to retain that information.

ENC Compilation Scale

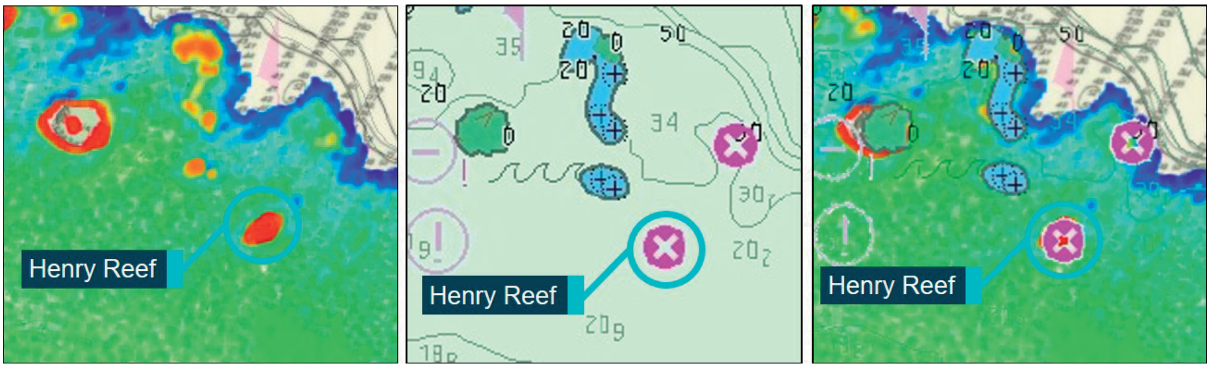
The viewing scale of a paper chart is determined and fixed by the cartographer at the chart compilation stage, so symbols are typically larger than the extent of the real-world feature they represent and do not change. The situation is different when ENCs are used in ECDIS as the Mariner can zoom in and out beyond the ENC compilation scale. Zooming in to a larger scale introduces the risk that any positional errors that may exist in the ENC data are magnified to a point where the data becomes unsafe to use – and this fact will not be immediately apparent as the ECDIS will continue to display the text and symbols at a fixed size.

ENC producers use a variety of methods to define the compilation scale of their ENC data, but for safety reasons these will always take into account the scale at which the source information was captured.

To ensure consistency, and thus contribute to improved display, most ENCs are assigned to one of the IHO's recommended standard compilation scales. These are defined within the IHO's S-65 publication, together with an example of the navigational purpose to which each ENC scale may be assigned.

The various compilation scales define the level of detail that can be included, and how that detail is depicted. While a feature may be depicted as an area or line feature at a large compilation scale, it may be depicted as a point feature at a smaller scale. Some object classes within an ENC, such as wrecks, rocks and obstructions including reefs, may therefore be defined by the cartographer as points, lines or areas depending on the compilation scale of the ENC and other factors. One major factor is whether the symbol for a feature will be larger than its true (real-world) extent, if known, at the chosen compilation scale.

Charted point features only indicate that a certain feature object exists in a given point location. While a light beacon may be charted as a point feature, a point feature may also define the approximate centre of a feature that actually has an 'area', such as a small reef. This means that, unlike charted area features, the only positional information available for a point feature is its geographical position (a point represented by latitude and longitude coordinates), and not its true extent (such as the distance from the charted point centre of a reef to its edge). This is particularly important in ECDIS where the Mariner chooses to over-scale the chart display (see Figure 8)



Reef as per source data | Isolated danger point symbol on ECDIS | Point symbol against source data extents

Figure 1: *Comparison of small reef within source data at ENC compilation scale, point symbol depiction on ENC, and source data overlaid on ENC*

Images show survey data (left), section of ENC (centre) and ENC superimposed on survey data at compilation scale (right).

Source: *Australian Hydrographic Office (AHO) and ATSB*[1].

1 Australian Transport Safety Bureau

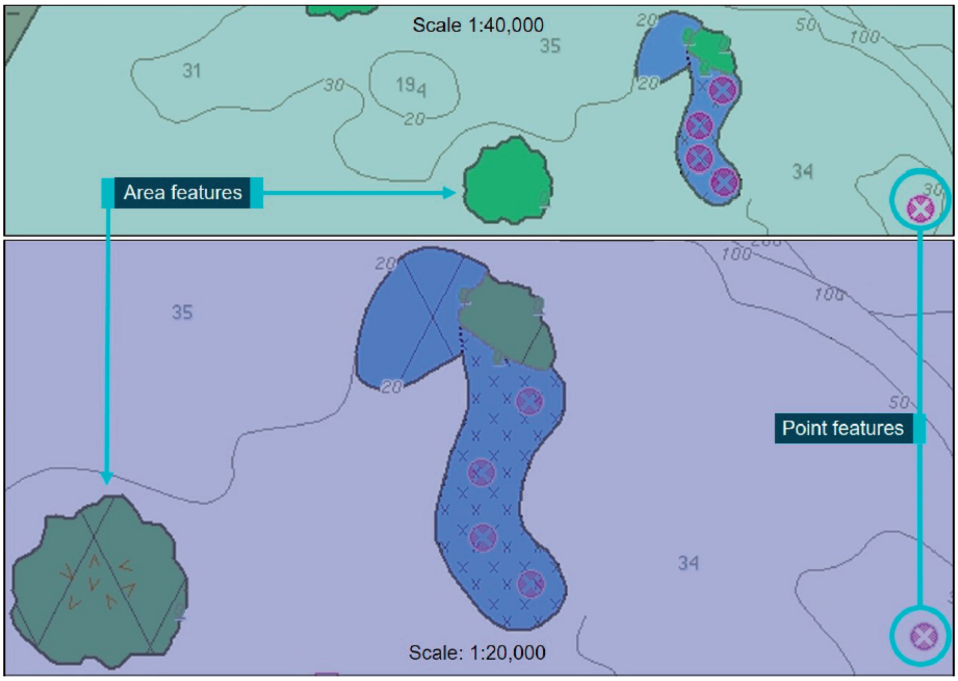


Figure 2: *Comparison of area features and point features at different scales*

These images show the same ENC displayed at two differing scales. The two images demonstrate a key difference between point and area features – area features change size in proportion to the ENC display scale, however the point features remain the same size regardless of display scale.

Source: *Electrotech, annotations by the AHO.*

ECDIS safety checking function

Since July 2018 all SOLAS vessels of 500GT and upwards are required to be using ENCs created by Hydrographic Offices in type-approved ECDIS equipment. The use of ENCs within ECDIS provides a wide range of advantages; it simplifies voyage planning, allowing easy modification of routes and offers many safety benefits. Routes can be checked for potential dangers based on the safety parameters input by the Mariner. The safety contour defines the safe water the vessel can navigate in based on the depth areas and contours included in the ENC; and the safety depth defines isolated dangers that are located in otherwise "safe" water. During route monitoring it is also possible for the ECDIS to be configured to alarm and indicate on features set by the Mariner, alerting navigators to impending dangerous situations.

IMO Resolution A.893(21) adopted on 25 November 1999 Guidelines for Voyage Planning states that;

> '(2.1) *All information relevant to the contemplated voyage or passage should be considered. The following items should be taken into account in voyage and passage planning: appropriate scale, accurate and up-to-date charts to be used for the intended voyage or passage, as well as any relevant permanent or temporary notices to mariners and existing radio navigational warnings.*'

This clause requires vessels to carry all appropriate scale ENCs for their intended voyage, thus minimizing any effects of generalization and ensuring the ECDIS can alert the Mariner to dangers by using the largest scale data available.

IMO Performance Standard for ECDIS (11.4.6) requires;

> '*An indication should be given to the mariner if, continuing on its present course and speed, over a specified time or distance set by the mariner, own ship will pass closer than a user-specified distance from a danger (e.g. obstruction, wreck, rock) that is shallower than the mariner's safety contour or an aid to navigation.*'

The route checking functions built into ECDIS to check and monitor a route for dangers is a fundamental safety benefit for Mariners. Where passage planning is conducted on ECDIS, use of the route checking function is a key component of the overall process of checking the suitability of a planned route and complements the visual check of that route.

The route checking function is dependent upon a number of parameters set by the Mariner as part of setting up the ship's ECDIS for the voyage. These parameters include a vertical accuracy component, resulting in a safety depth setting; and a horizontal accuracy component, which includes both an allowance for the accuracy of the ship's navigation system and a minimum permissible planned distance from dangers. These settings may be changed for different voyages, and even different phases of a voyage, based on the bathymetric data quality information included in the ENC (such as the Category of Zone of Confidence in Data (CATZOC) attribute on the mandatory Quality of Data (M_QUAL) feature). The settings combine to create a route safety region around a vessel's planned track.

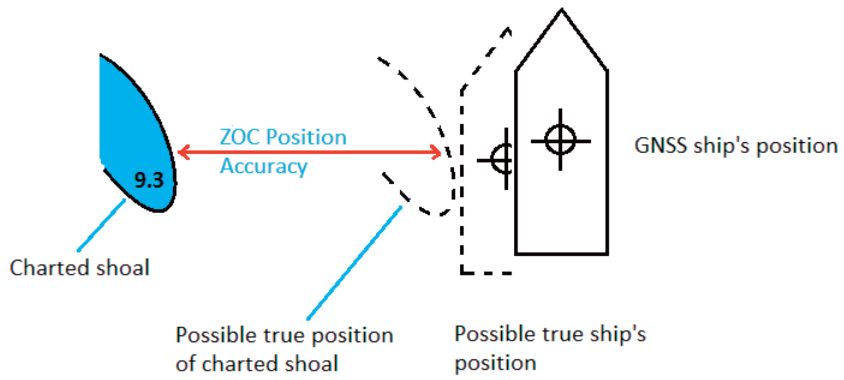


Figure 3: *The component parts of determining an appropriate route safety region around a vessel's planned track*

Figure 3 shows the minimum considerations when determining what allowance should be made for charted dangers on or near a planned route. These include allowances for the accuracy of the ship's positioning system, and for the accuracy of the chart. The dashed lines indicate the possible worst-case scenario for the Mariner.

Source: *AHO.*

The ECDIS safety checking function verifies the user-defined safety corridor against the entire chart database in the ECDIS for dangers, not just against the extent of visual point symbols displayed on screen. The ECDIS will graphically identify points along the proposed route that are a danger to the vessel and return a textual list of the same hazards.

ECDIS safety check only verifies data along the user-defined corridor; the width of the corridor is set by the Cross Track Distance (XTD). The safety check will be performed against the largest scale information within the ECDIS system irrespective of the ECDIS display scale. Point features will only be identified as hazards if they fall within the safety zone being checked regardless of the size of the symbol displayed on screen and regardless of the actual extent of the physical feature it represents. Due to the compilation scale of the ENC there could be occasions where the charted point feature may not represent the full extent of the real-world feature. The Mariner must therefore ensure his safety corridor XTD is sufficiently wide enough to identify all navigational dangers along the intended route. Mariners are also required to conduct a thorough visual check of the intended route to complement the automated safety check.

The two following fictitious examples show how a hazardous point feature could be missed if the correct ENC scale charts are not loaded in the ECDIS and route XTD is not adequately set.

Example 1

In the first example (Figure 4), the charted position of the 'isolated danger' point feature representing the reef lies about 55m to the east of the planned route and falls within the route safety region. As this point lies within the route safety region set by the Mariner, the ECDIS will detect the reef as a danger close to the planned route and include it in the list of dangers for that leg of the route.

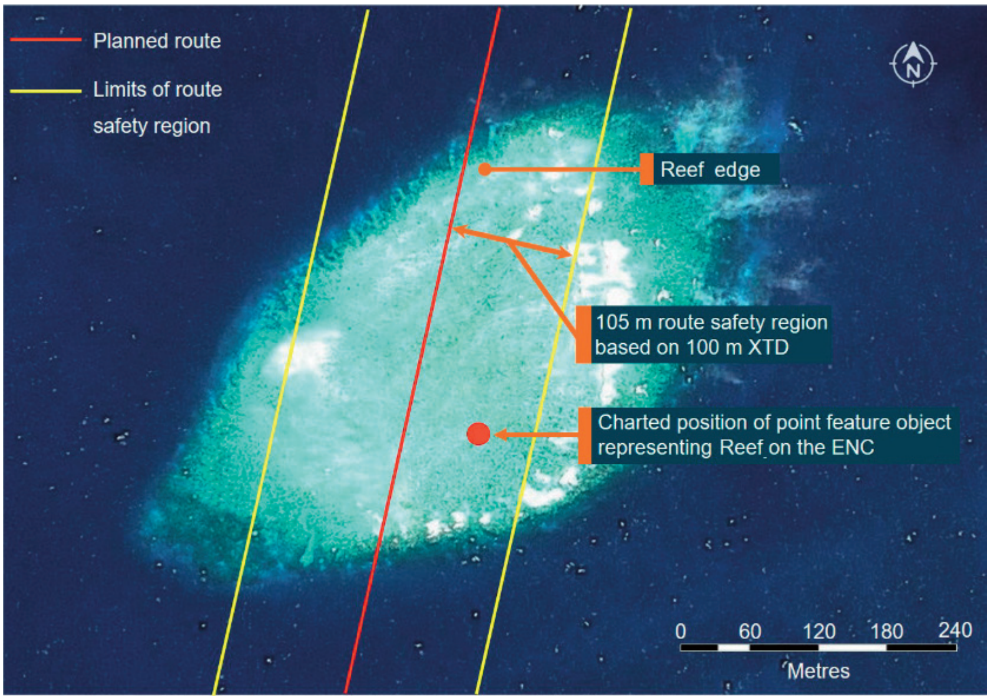


Figure 4: *Planned route covers the position of the point symbol* [2]

Figure 4 shows the planned route and the ECDIS route safety region based on a 100m Cross Track Distance (XTD) near the point position used to represent the reef within the ENC. Note that the charted point position lies within the route safety region and will result in an ECDIS alert.

Source: *DigitalGlobe, Esri, modified and annotated by the ATSB and the AHO.*

[2] Scale of Figure is approximately 1:6000; scale of ENC containing the point symbol is 1:90000.

Example 2

In the second example (Figure 5), the planned route lies 55m further to the west. The charted position of the point feature now lies outside the ECDIS route safety zone set by the Mariner. In this case, the ECDIS will not detect the reef as a danger on or close to the planned route. However, the reef still clearly presents a danger to the ship.

In this situation, if the vessel has not taken into account the possibility of isolated reefs within the region, and resultantly extended the XTD to at least account for the horizontal accuracy component of the underlying quality information (CATZOC), there is a possibility the danger could be missed during the visual inspection and the vessel could potentially run aground without the ECDIS indicating the danger on the planned route.

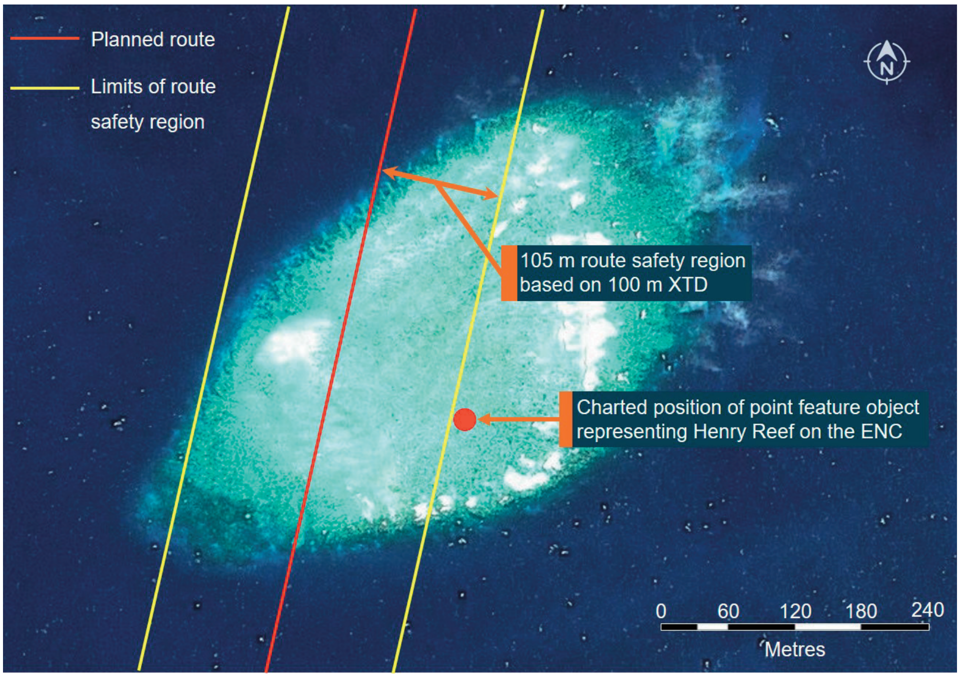


Figure 5: *Planned route misses the position of the point symbol*

Figure 5 shows a similar planned route and route safety region, 55m further west, near the same point position used to represent the reef within the ENC. The charted point position now lies outside the route safety region and therefore no longer results in an ECDIS alert. However the route still passes over the true reef extent.

Source: *DigitalGlobe, Esri, modified and annotated by the ATSB and the AHO.*

Given the size of the reef in the examples, it must be stressed that it would typically warrant capture by the cartographer as an area feature within an ENC compiled at the scale of the examples; and only at significantly smaller compilation scales would it be captured as a point feature.

A similar scenario and associated safety implications equally applies to the ECDIS look-ahead function and XTD once the ship is underway and monitoring along the planned route.

ENC over-scaling

A key difference to note between charted area features and point features on an ECDIS display is that area features change size in proportion to the scale at which the ENC is being viewed, whereas point feature size remains constant irrespective of display scale (see Figure 2); in other words they are not enlarged as viewing scale is increased.

Additionally, the size and shape of the point symbol does not necessarily represent the size or shape of the physical, real-world feature it is depicting.

Traditionally, nautical cartographers have sought to ensure that the symbol on the chart is larger than the real-world feature it represents when seen at the chart's compilation scale. Navigational purpose is also taken into consideration; a chart that is intended for coastal navigation, where it is not intended that the chart is to be used for close approach to isolated features, may also factor into the decision of the cartographer as to whether to depict a feature as an area or a point symbol on the chart. This practice remains true in the preparation of ENC, where the compilation scale defines the maximum intended viewing scale for that ENC in ECDIS.

However, when the ENC is viewed at scales progressively larger than the compilation scale, the intended relationship between the point symbol and the area feature it represents is broken; as the ENC is progressively 'over-scaled' on screen, the symbol represents a progressively smaller proportion of the real-world feature, such as a reef area, on the ECDIS display. This can lead to an incorrect assumption by the Mariner that they may go closer to the edge of the point symbol when the display is 'over-scaled'; this would be a dangerous assumption.

As a point feature, a reef is charted in a specific latitude/longitude position on the ENC, typically representing the centre of the area of the reef. Visually, this means that the symbol representing the reef will always be centred on this position (see Figure 1); and when viewed at the ENC compilation scale, or smaller, the symbol will typically cover the true extent of that reef. On the ECDIS display, the symbol always maintains an absolute size of 7mm in diameter regardless of the scale at which the ENC is viewed (see Figure 6). However, if the display scale has been over-scaled to twice the ENC compilation scale, a considerable extent of the reef (previously covered by the symbol), may now extend well beyond the symbol, without any indication of such in the ECDIS (see Figure 8).

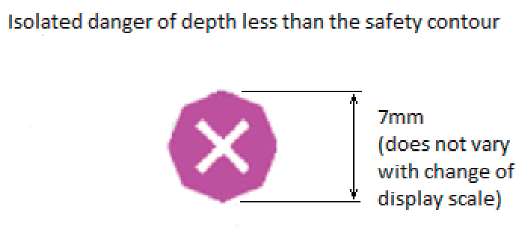


Figure 6: *Isolated danger (point) symbol in ECDIS*

Source: *IHO.*

The ECDIS has the functionality to allow ENCs to be displayed at scales larger than the original compilation scale. However, the ability to zoom in beyond the compilation scale (the maximum intended viewing scale) has introduced an inherent risk that is not present in paper charts. To minimize these risks, ECDIS includes indicators to alert when an ENC is being viewed beyond the maximum intended viewing scale.

1. Over-scale indication shown within the graphical user interface
2. Over-scale (jail bar) pattern

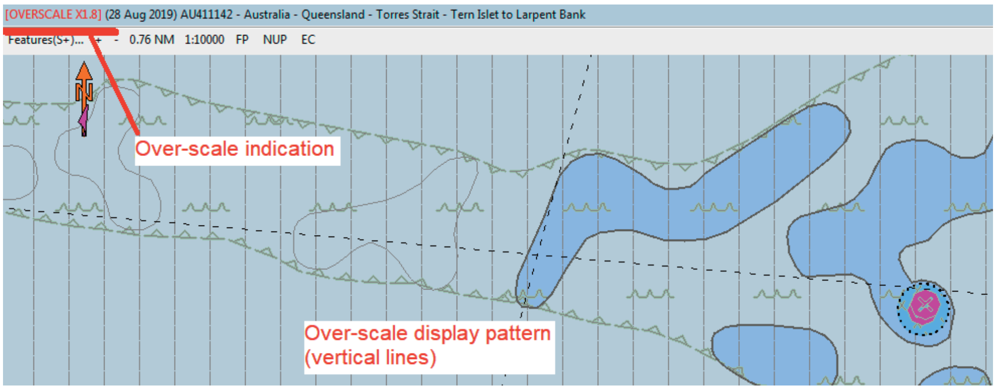


Figure 7: *Over-scale indication and over-scale pattern on ECDIS*

Source: *AHO.*

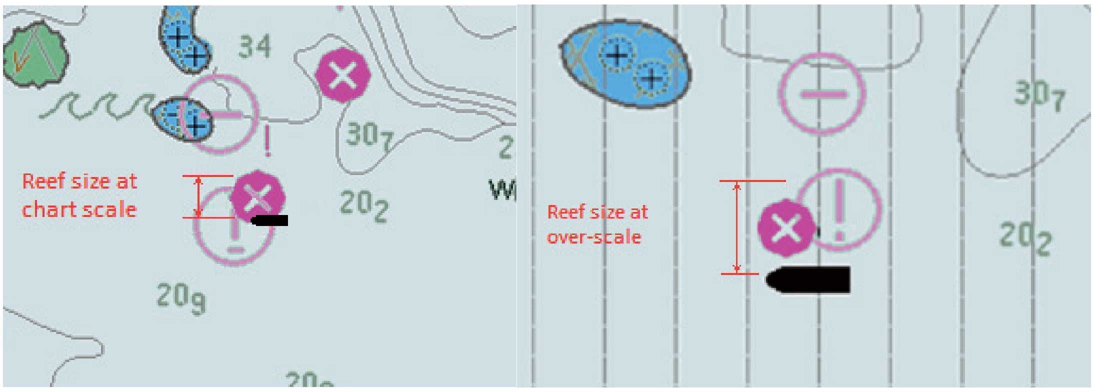


Figure 8: *Over-scale indication and over-scale pattern on ECDIS*

In the image on the left, shown at maximum intended viewing scale, a Mariner can immediately see that passing close to the charted isolated danger would be unwise. In contrast, in the image on the right, shown over-scaled, passing the same distance from the same isolated danger appears safe. Unfortunately, as the symbol has not been enlarged in proportion to the display scale, it no longer fully covers the reef, resulting in a hazardous navigation situation.

Source: *AHO.*

It is important to also note that the ECDIS will provide an indication if the ship's position is covered by an ENC at a larger scale than the current ENC being used in the ECDIS display.

Conclusions and recommendations

With many additional ENC tools capable of planning routes the Mariner must still be aware that only the ECDIS is certified for carrying out route planning and monitoring. To ensure safety and compliance it is imperative that all the appropriate scale ENCs are used in the ECDIS for adequate route planning and monitoring. The route must be automatically safety checked and a visual inspection performed at the largest scale possible, based on the available portfolio of ENCs, before the voyage commences. To ensure all dangers are identified by the ECDIS auto safety check function the Cross Track Distance must be appropriately set, taking into account factors such as the accuracy of the ship's positioning and navigation system; the bathymetric data quality information included in the ENCs (such as CATZOC); and the intended navigational purpose of the ENCs loaded into the ECDIS.

There is a common misconception by some Mariners that zooming in beyond the compilation scale of the ENC allows for greater accuracy – however, this is not the case. In reality zooming in beyond the intended maximum display scale of ENCs may be misleading and dangerous, particularly for 'isolated dangers of depth less than the safety depth'.

The risks associated with over-scaling the ENC within ECDIS are two-fold:

Firstly, the symbol selected by the cartographer to represent a real-world feature may no longer fully cover that feature.

Secondly, but most importantly, because the text and point symbols stay the same size within the over-scaled ENC, any sense of appropriate distance from a potential danger is no longer intuitive and can result in a false sense of safety that does not reflect reality.

Mariners are strongly advised not to zoom in ECDIS beyond the compilation scale to a point where the ECDIS over-scale indication or pattern are triggered.

Some ECDIS allow the operator to turn off over-scale warnings. This is not recommended under normal circumstances.

Familiarization with all the core functions of the ECDIS are mandatory requirements within STCW and are essential for safe navigation. Mariners must be familiar with the properties of the ECDIS; and develop a sufficient understanding of how and when the ECDIS indicates that ENC data is being displayed at an unsafe scale, so that the display settings can be adjusted accordingly.

Use of ENCs in ECS

Many ECS are able to use ENCs. However, because an ECS, by definition, is not type-approved as meeting the ECDIS performance standards, the use of ENCs in an ECS does not satisfy the ECDIS carriage requirements of SOLAS.

ENC Distribution

The provision of a timely, reliable, worldwide and uniform ENC data distribution service is a major organizational challenge and the IHO developed the WEND (World-wide ENC Database) concept to meet these requirements. The purpose of WEND is to ensure a world-wide consistent level of high-quality, updated official ENCs through integrated services that support chart carriage requirements of SOLAS Chapter V, and the requirements of the IMO Performance Standards for ECDIS. The WEND Principles are included as Resolution 1/1997 (as amended) in IHO publication M-3 (*www.iho.int > Standards & Publications > M-3*). The WEND Working Group (WENDWG) has also produced "Guidelines for the Implementation of the WEND Principles" which are available from the WENDWG document page (*www.iho.int > Committees & Working Groups > WEND*). WEND consists of two components:

- A charter that describes the principles governing cooperation between the worlds Hydrographic Offices producing ENCs. Principles include:
  - The organization responsible for the primary charting of an area is responsible for ENC production in that area;
  - The relevant IHO standards, especially S-57 must be followed; and
  - The rules of a recognised work quality assurance system (such as ISO 9000) should be applied to ENC production.
- A conceptual schema describing a network of Regional Electronic Chart Co-ordinating Centres (RENCs), where:
  - Each RENC takes responsibility in its area for the collation of ENCs and updates for the region;
  - Each RENC can offer an identical global dataset for ECDIS through the exchange of the regional datasets and their updates between all the RENCs, and
  - RENCs act as a wholesale outlet for ENCs. RENCs supply ENCs to commercial user service providers who - rather like paper chart distribution - tailor individual sets of chart data for the special needs of a shipping company or a particular ship.
- Producer Member States are encouraged to distribute their ENCs through a RENC. Those not opting to join a RENC should make appropriate arrangements to ensure that their ENCs meet WEND requirements for consistency and quality and are widely distributed.

To date, two RENCs – PRIMAR, based in Norway; and IC-ENC, based in the United Kingdom, Australia and the Americas, are in operation. The RENC model has yet to be fully adopted by all ENC producing nations. A number of nations still distribute their ENCs individually either through individually appointed chart data suppliers or directly rather than through RENCs.

Because ENCs might be subject to unauthorised amendment or illegal copying, the IHO has adopted S-63 – "*The IHO Data Protection Scheme*". This provides a standard authentication and encryption for ENCs. S-63 defines the technical details of the encryption method and the operating procedures for the RENC and ENC distributors. It also provides specifications that allow ECDIS manufacturers (OEMs) to build systems that can authenticate and decrypt S-63 ENCs.

What is a SENC?

In order to get efficient data structures that facilitate the rapid display of ENC data, most ECDIS convert each ENC dataset from S-57 into an internal machine-language format called SENC or System ENC – which is optimised for chart image creating routines. Most ECDIS software manufacturers have their own SENC format.

SENC Delivery

In order to take advantage of the efficiencies of delivering ENC data in a SENC format, the IHO has authorised an optional distribution mechanism called SENC delivery. This is in addition to the standard distribution of ENC in S-57 format. In this case, a RENC delivers the S-57 based ENCs to an authorized chart data distributor who then performs an ENC-to-SENC conversion (that otherwise would take place inside the ECDIS), and delivers the resultant SENC to the end user.

However, it is up to individual Hydrographic Offices to decide whether they wish to allow the ENCs for their waters to be distributed in SENC format in addition to S-57. Not all Hydrographic Offices allow their ENCs to be delivered by distributors as SENCs.

Official and Unofficial Data

An ECDIS can determine if data is from either an ENC or a private source by interrogating the Agency Code (a two character combination which is unique for any data producer) embedded in the data.

Using this code an ECDIS will warn mariners that they must navigate with an official up to date paper chart if data from a private source is in use. The ECDIS will show a warning on the ECDIS screen:

«No Official Data -Refer to paper chart »

What scale should an ENC be displayed at?

During production, ENCs are assigned a compilation scale based on the nature of the source data upon which they are based and their intended usage. They are also allocated to a Navigational Purpose related to this. This is analogous to a series of paper charts covering the same area, ranging from “small scale charts” to “large scale plans”. As shown in the table below there are six Navigational Purposes (NOTE: scale ranges are indicative only).

Suggested assignment of Navigational Purposes to scale ranges

Navigational Purpose	Name	Scale Range
1	Overview	<1:1 499 999
2	General	1:350 000 – 1:1 499 999
3	Coastal	1:90 000 – 1:349 999
4	Approach	1:22 000 – 1:89 999
5	Harbour	1:4 000 – 1:21 999
6	Berthing	> 1:4 000

To facilitate the display of a radar overlay on ENCs, the IHO specifications recommend that hydrographic offices set the compilation scales of their ENCs to be consistent with the standard radar range scales as shown in the following table:

Radar range / standard scale

Selectable Range	Standard scale (rounded)
200 NM	1:3 000 000
96 NM	1:1 500 000
48 NM	1:700 000
24NM	1:350 000
12 NM	1:180 000
6 NM	1:90 000
3 NM	1:45 000
1.5 NM	1:22 000
0.75NM	1:12 000
0.5 NM	1:8 000
0.25 NM	1:4 000

How are ENCs named?

Each ENC is identified by an 8-character identifier, for example FR501050. The first two characters indicate the producer; for example FR for France, GB for United Kingdom of Great Britain and Northern Island. A complete list of producer codes is included in the IHO standard S-62 – "*List of Data Producer Codes*". The third character (a number from 1 to 6) indicates the Navigational Purpose (as shown in the table above). The last five characters are alpha- numeric free text and provide a unique identifier.

Updating ENCs

In principle the generation and distribution of regular updates for ENCs follows a similar organizational structure to the production and distribution of ENCs. The frequency of updates (including permanent updates and updates equivalent to the content of Temporary (T) and Preliminary (P) paper chart Notices to Mariners) is normally synchronised with the chart corrections promulgated by national Notice to Mariners for the affected sea areas.

Updates may reach a ship via different ways depending upon the capabilities of the ENC service provider and the communication facilities onboard:

- On data distribution media, for example CD;
- As an e-mail attachment via SATCOM; and
- As a broadcast message via SATCOM plus additional communication hardware.

Raster Navigational Charts (RNCs)

General principles

RNCs are digital copies of paper charts conforming to IHO publication S-61 - *Product Specifications for Raster Navigational Chart (RNC)*. RNCs are issued by, or on the authority of a national Hydrographic Office.

When displayed on an ECDIS screen RNCs appear as a facsimile of the paper chart however, they contain significant metadata to ensure that they have a certain minimum functionality; such as a geo-referencing mechanism that allows geographic positions to be applied to and extracted from the chart, automatic updating of the RNC from digital files (and the ability to show the state of correction), and the display of the RNC in day or night colours.

An RNC is a digital copy of the current paper chart. As such the chart content cannot be analysed by a computer program to trigger alarms and warnings automatically as is the case with a vector chart; however, some alarm and warning functions can be achieved by manual user input to the ECDIS.

RNC data format and production

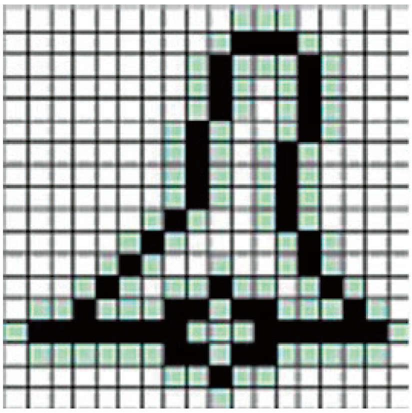
RNCs are normally produced by digitally scanning the stable repromat used to make a paper chart, or direct conversion of a completed compilation of a paper chart in a digital chart production system to a raster format. Unlike ENCs there can be more than one format for RNCs. The main RNC formats are:

- BSB (used by USA, Canada, Cuba and Argentina); and
- HCRF (used by UK and New Zealand).

RNC Display

- The display of RNCs is limited by the resolution at which they were scanned. Excessive zooming in or out of the image seriously degrades the clarity of the image (see figure below). When the user wants to see a representation of a geographic area in greater detail, then just like a paper chart, a larger scale RNC should be selected (if it exists);
- Orientation of the Raster Chart Display System (RCDS) display to other than north-up (for example course-up or route-up), may affect the readability of chart text and symbols;
- RNCs incorporate very similar colour palettes to the day/night colours used by ENCs. It is mandatory for ECDIS with an RCDS capability to provide the appropriate colour palettes for RNCs;

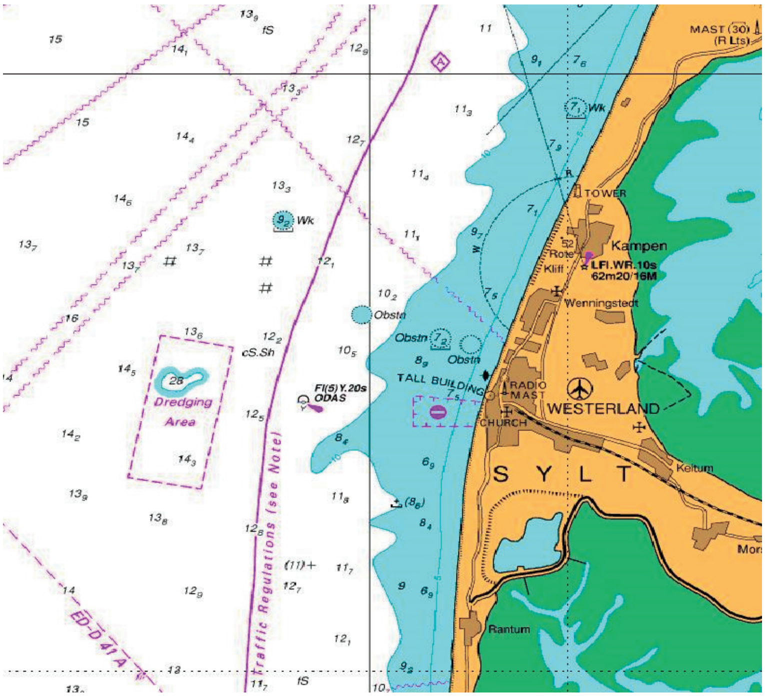
- RNCs are treated as individual charts (not seamless like ENCs). However, it is possible for ECDIS to automatically load an adjoining chart, based on the meta data provided;
- ARPA radar targets can be overlaid onto an RNC. It is also possible for a radar video image to be scaled to fit an RNC. Scaling an RNC to fit a radar video image is inappropriate as this is likely to result in a degraded chart image; and
- RNCs include significant meta data to allow an ECDIS to make maximum use of the image. For example chart notes and tide panels may be accessed directly in RCDS mode rather than the user having to scroll to the appropriate area of the chart.



"Over-zoomed" symbol on a raster chart

The image of an RNC retains the horizontal datum of the paper chart from which the RNC has been derived. However, the geo-referencing of the RNC can include an adjustment to account for the use of GNSS and the WGS 84 datum. Mariners should understand how the horizontal datum of the original chart relates to the datum used by the ships position fixing system. In some instances, this will appear as an apparent shift in geographical position. (Any differences will be most noticeable at grid intersections and during route monitoring). Where the difference between the local horizontal datum and WGS 84 is known, the adjustment should be automatically applied by the ECDIS. If the horizontal datum of the paper chart from which the RNC is produced is not known then it is not possible to relate GNSS positions accurately to the RNC; IMO SN/Circ.255 has been issued to alert users to this problem.

Below are illustrated Day and Night colour schemes of a RNC:



RNC Display, day

RNC Display, night

RNC updating

- RNC updates can be supplied as complete refreshed images or as patches (tiles or areas) that the ECDIS can superimpose on the original RNC. The latter method is normally used as this minimises the amount of data to be provided;
- Updates are provided in line with those made available via the Notices to Mariners system for the equivalent paper chart; and
- Most RNC services currently rely on CD as the transfer media; however electronic courier services are now being established to allow mariners to download selected chart updates.

Private Chart Data

Privately produced chart data may be provided in either vector or raster formats and superficially might seem similar to official chart data. However there are important differences in the type and quality of data being sold and while many companies take care in the production of electronic chart data to ensure both completeness and accuracy, this cannot be assumed for all.

Private chart data cannot be updated with the same regularity as official data. The private chart data suppliers normally base their products on official charts and data (supplied by HOs under licence). This means that the updating of their charts depends on the availability of the updated official chart product. Consequently there is a delay, sometimes considerable, between the promulgation of the updates for the official charts and the release of updates for private chart data.

Chart data published by private companies is not quality controlled or assured by a Government organization; therefore the product liability is entirely the responsibility of the producing company.

In 2003 ISO published a specific standard (ISO 19379:2003) for the compilation of private chart data for use in Electronic Chart System (ECS); this standard was produced on the initiative of the private chart data industry. ISO 19379 applies to both private vector charts and to private raster charts. It includes test methods for the production of an ECS database and addresses the elements of the database relevant to safety of navigation including content, quality and updating. It also provides guidance on the production and testing of an ECS database. It does not cover the methods and techniques required for database design and development, nor does it address specific quality management procedures. Private chart data, regardless of the format in which it is supplied to the market or any ISO certification, does not meet the requirements specified by the IMO Performance Standards for ECDIS and thus does not meet the chart carriage requirements.

In contrast to ENCs and RNCs many proprietary formats are used. Consequently, chart data from different manufacturers are often incompatible with each other – and so are the ECS which make use of them.

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SECTION 5: ECDIS CYBER SECURITY

TBC

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SECTION 6: REFERENCES AND GLOSSARY

References

- International Convention for the Safety of Life at Sea (SOLAS)
- International Convention for Standards for Training, Certification and Watchkeeping (STCW)
- IMO Resolution MSC.232 (82): Revised Performance Standards for ECDIS
- IEC 61174: Electronic chart display and information system (ECDIS) - Operational and performance requirements, methods of testing and required test results
- IEC 62288: Maritime navigation and radiocommunication equipment and systems - Presentation of navigation-related information on shipborne navigational displays – General requirements, methods of testing and required test results
- The latest versions of the following IHO ECDIS and ENC Standards can be accessed from: *www.iho.int > ENCs & ECDIS > Current ENC and ECDIS Standards*.
- IHO S-52: Specifications for Chart Content and Display Aspects of ECDIS;
- IHO S-57: IHO Transfer Standard for Digital Hydrographic Data
- Appendix B.1 – ENC Product Specification
- IHO S-61: IHO Product Specification for Raster Navigational Charts
- IHO S-62: IHO List of Data Producer Codes
- IHO S-63: IHO Data Protection Scheme.
- ENC related IHO S-100 based Specification under development:
- IHO S-101: ENC Product Specification

For information on the latest versions of documents mentioned above, consult the web site of the issuing Organization:

International Maritime Organization	www.imo.org
International Hydrographic Organization	www.iho.int
International Electrotechnical Commission	http://www.iec.ch

- Links to the following IMO Circulars may be found on the IHO web site *http://iho.int/iho_pubs/IHO_Download.htm*, under the table entry for S-66, as supplementary reference documents to S-66:
- IMO MSC.1/Circ.1503 (as amended) *ECDIS – Guidance for Good Practice*;
- IMO STCW.7/Circ.24 (as amended) *INTERNATIONAL CONVENTION ON STANDARDS OF TRAINING, CERTIFICATION AND WATCHKEEPING FOR SEAFARERS (STCW), 1978, AS AMENDED - Guidance for Parties, Administrations, port State control authorities, recognized organizations and other relevant parties on the requirements of the STCW Convention, 1978, as amended*;
- IMO SN.1/Circ.213 *Guidance on Chart Datums and the Accuracy of Positions on Charts*;
- IMO SN.1/Circ.255 *Additional Guidance on Chart Datums and the Accuracy of Positions on Charts*.

GLOSSARY/LIST OF ABBREVIATIONS

Abbreviation	Explanation
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
BIMCO	The world's largest Association of ship-owners and others representing more than 65% of the world's tonnage
BSB	Raster data format used by USA and Canada and others (BSB comes from the first letter of the companies that joined together with NOAA to make the first NOAA raster charts: Better Boating Association, Sewall Company and Blue Marble Geographics)
ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System (does not meet SOLAS requirements)
ECS charts	Non official (private) chart data (vector or raster)
ENC	Electronic Navigational Chart
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HCRF	Hydrographic Chart Raster Format
Hydrographic Office (HO)	National Hydrographic Office
IC-ENC	International Centre for ENC's - a RENC operated by UK Hydrographic Office and in collaboration with the Australian Hydrographic Service, Brazil Directorate of Hydrography and Navigation and NOAA
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
ISM	International Safety Management code
ISO	International Organization for Standardization
MED	Maritime Equipment Directive of the European Union
PRIMAR	a RENC operated by the Norwegian Hydrographic Service
PSC	Port State Control
PSCO	Port State Control Officer
RCDS	Raster Chart Display System
RENC	Regional ENC Coordination Centre
RNC	Raster Navigational Chart
RTCM	Radio Technical Commission for Maritime Services
SATCOM	Satellite Communications
SENC	System ENC
SOLAS	International Convention for the Safety of Life at Sea
WEND	World-wide ENC Database
WGS 84	World Geodetic System 1984

Further Reading

The Electronic Chart – Fundamentals, Functions, Data and Other Essentials – A Textbook by H.Hecht, B. Berking, G. Büttgenbach, M. Jonas, L. Alexander; 3rd revised edition; 2011; Publisher: Geomares Publishing; ISBN: 978-90-806205-8-2

From Paper Charts to ECDIS – A Practical Voyage Plan; by Harry Gale; February 2009; Publisher: The Nautical Institute; ISBN 978 1 870077 98 9

ECDIS and Positioning, Vol 2 of Integrated Bridge Series; by Dr Andy Norris; January 2010; Publisher: The Nautical Institute; ISBN 978-1-906915-11-7

The Electronic Chart Display and Information System - An operational handbook by Adam Weintrit, Navigational Department, Gdynia Maritime University, Poland.; 1st edition; 2009; Publisher: CRC Press; ISBN: 978-0-415-48246-2

INFORMATION ON ENC GENERALIZATION, OVER-SCALING AND SAFETY CHECKING FUNCTIONS IN ECDIS

Executive summary

This information paper focuses on the importance of understanding ENC compilation scale and the safety implications of using ENC data beyond its intended usage, during both the Electronic Chart Display and Information Systems (ECDIS) route planning and checking and route monitoring phases of navigation.

The paper provides ECDIS users with information regarding the process Hydrographic Offices employ to transform the physical world into a 2D Electronic Navigational Chart (ENC) that can be used in an ECDIS. Within the paper the following topics are covered:

Cartographic generalization practices

For centuries marine cartographers have been using generalization techniques to transform our view of the world from a true three-dimensional reality to a scaled, two-dimensional abstract view. Many aspects to generalization are used by Hydrographic Offices when creating navigational products: classification, simplification, exaggeration, and symbolization.

Classification: Groups features into classes having identical or similar attributes. Organizing features into fewer classes helps to simplify and clarify the message of the navigational chart.

Simplification: Features are simplified by either smoothing or compacting. Smoothing is generally used for linear features such as depth contours and coastlines where each curve cannot be depicted because of scale or because the detail would clutter the chart.

IHO Chart Specification S-4 states *'Contours should be smoothed only where it is necessary to remove intricacies which would confuse mariners. Where necessary, smoothing will include deeper water within shoaler contours (that is: it must be shoal-biased), but an attempt to retain a reasonable representation of the seabed should be made'.*

In compacting, if there are many features in a small area, such as isolated rocks which will just be dots at chart scale; those features may be grouped (compacted) within a single obstruction area.

Exaggeration: Due to scale, certain features must be shown larger than their actual relative size. Dangerous features such as rocks, wrecks and obstructions would at certain scales be unreadable if shown at their correct size, so they are exaggerated enough to be recognized and to show their relationship to other similar features.

Symbolization: Symbols are used on charts to inform the Mariner what features are. Nautical chart symbols use shape and colour to help the Mariner quickly understand the importance of certain features. For example, the colour magenta is generally reserved for drawing attention to symbols for features which have a significance extending beyond their immediate location; or are not themselves a physical feature (such as administrative and restricted areas; or routeing measures).

Globally accepted cartographic practices include the use of point symbols to represent real-world area features when the scale of the product is reduced but the importance of the feature is such that the cartographer wants to retain that information.

ENC Compilation Scale

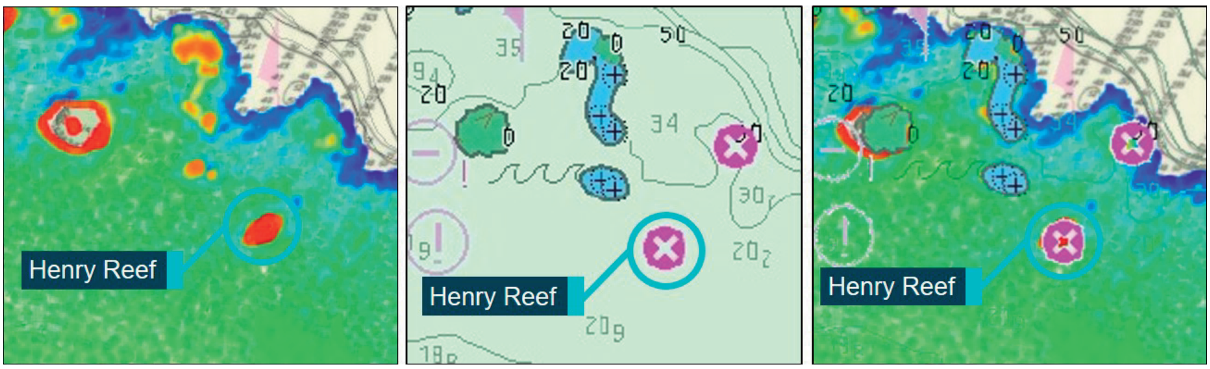
The viewing scale of a paper chart is determined and fixed by the cartographer at the chart compilation stage, so symbols are typically larger than the extent of the real-world feature they represent and do not change. The situation is different when ENCs are used in ECDIS as the Mariner can zoom in and out beyond the ENC compilation scale. Zooming in to a larger scale introduces the risk that any positional errors that may exist in the ENC data are magnified to a point where the data becomes unsafe to use – and this fact will not be immediately apparent as the ECDIS will continue to display the text and symbols at a fixed size.

ENC producers use a variety of methods to define the compilation scale of their ENC data, but for safety reasons these will always take into account the scale at which the source information was captured.

To ensure consistency, and thus contribute to improved display, most ENCs are assigned to one of the IHO's recommended standard compilation scales. These are defined within the IHO's S-65 publication, together with an example of the navigational purpose to which each ENC scale may be assigned.

The various compilation scales define the level of detail that can be included, and how that detail is depicted. While a feature may be depicted as an area or line feature at a large compilation scale, it may be depicted as a point feature at a smaller scale. Some object classes within an ENC, such as wrecks, rocks and obstructions including reefs, may therefore be defined by the cartographer as points, lines or areas depending on the compilation scale of the ENC and other factors. One major factor is whether the symbol for a feature will be larger than its true (real-world) extent, if known, at the chosen compilation scale.

Charted point features only indicate that a certain feature object exists in a given point location. While a light beacon may be charted as a point feature, a point feature may also define the approximate centre of a feature that actually has an 'area', such as a small reef. This means that, unlike charted area features, the only positional information available for a point feature is its geographical position (a point represented by latitude and longitude coordinates), and not its true extent (such as the distance from the charted point centre of a reef to its edge). This is particularly important in ECDIS where the Mariner chooses to over-scale the chart display (see Figure 8)



Reef as per source data

Point symbol against source data extents

Isolated danger point symbol on ECDIS

Figure 1: Comparison of small reef within source data at ENC compilation scale, point symbol depiction on ENC, and source data overlaid on ENC

Images show survey data (left), section of ENC (centre) and ENC superimposed on survey data at compilation scale (right).

Source: Australian Hydrographic Office (AHO) and ATSB[1].

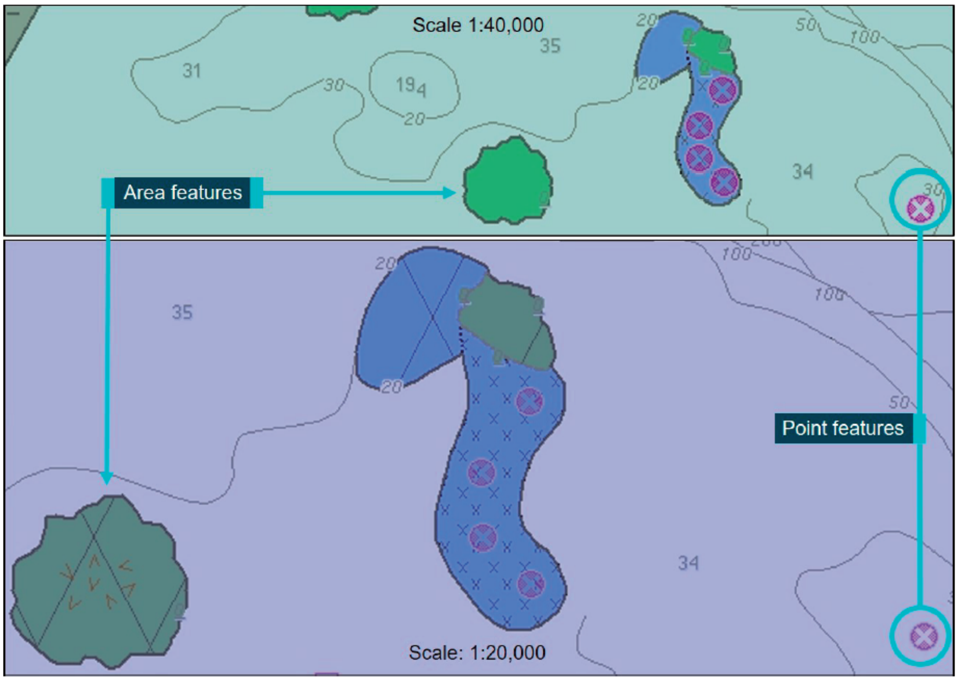


Figure 2: Comparison of area features and point features at different scales

These images show the same ENC displayed at two differing scales. The two images demonstrate a key difference between point and area features – area features change size in proportion to the ENC display scale, however the point features remain the same size regardless of display scale.

Source: Electrotech, annotations by the AHO.

ECDIS safety checking function

Since July 2018 all SOLAS vessels of 500GT and upwards are required to be using ENCs created by Hydrographic Offices in type-approved ECDIS equipment. The use of ENCs within ECDIS provides a wide range of advantages; it simplifies voyage planning, allowing easy modification of routes and offers many safety benefits. Routes can be checked for potential dangers based on the safety parameters input by the Mariner. The safety contour defines the safe water the vessel can navigate in based on the depth areas and contours included in the ENC; and the safety depth defines isolated dangers that are located in otherwise "safe" water. During route monitoring it is also possible for the ECDIS to be configured to alarm and indicate on features set by the Mariner, alerting navigators to impending dangerous situations.

IMO Resolution A.893(21) adopted on 25 November 1999 Guidelines for Voyage Planning states that;

'(2.1) All information relevant to the contemplated voyage or passage should be considered. The following items should be taken into account in voyage and passage planning: appropriate scale, accurate and up-to-date charts to be used for the intended voyage or passage, as well as any relevant permanent or temporary notices to mariners and existing radio navigational warnings.'

This clause requires vessels to carry all appropriate scale ENCs for their intended voyage, thus minimizing any effects of generalization and ensuring the ECDIS can alert the Mariner to dangers by using the largest scale data available.

IMO Performance Standard for ECDIS (11.4.6) requires;

'An indication should be given to the mariner if, continuing on its present course and speed, over a specified time or distance set by the mariner, own ship will pass closer than a user-specified distance from a danger (e.g. obstruction, wreck, rock) that is shallower than the mariner's safety contour or an aid to navigation.'

The route checking functions built into ECDIS to check and monitor a route for dangers is a fundamental safety benefit for Mariners. Where passage planning is conducted on ECDIS, use of the route checking function is a key component of the overall process of checking the suitability of a planned route and complements the visual check of that route.

The route checking function is dependent upon a number of parameters set by the Mariner as part of setting up the ship's ECDIS for the voyage. These parameters include a vertical accuracy component, resulting in a safety depth setting; and a horizontal accuracy component, which includes both an allowance for the accuracy of the ship's navigation system and a minimum permissible planned distance from dangers. These settings may be changed for different voyages, and even different phases of a voyage, based on the bathymetric data quality information included in the ENC (such as the Category of Zone of Confidence in Data (CATZOC) attribute on the mandatory Quality of Data (M_QUAL) feature). The settings combine to create a route safety region around a vessel's planned track.

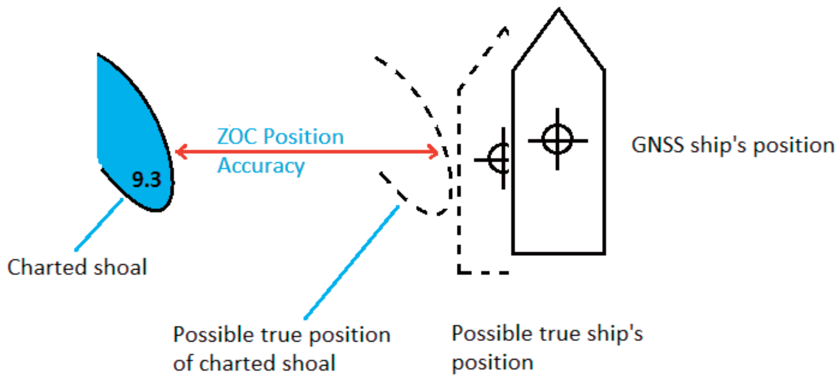


Figure 3: The component parts of determining an appropriate route safety region around a vessel's planned track

Figure 3 shows the minimum considerations when determining what allowance should be made for charted dangers on or near a planned route. These include allowances for the accuracy of the ship's positioning system, and for the accuracy of the chart. The dashed lines indicate the possible worst-case scenario for the Mariner.Source: Australian Hydrographic Office (AHO) and ATSB[1].

Source: AHO.

The ECDIS safety checking function verifies the user-defined safety corridor against the entire chart database in the ECDIS for dangers, not just against the extent of visual point symbols displayed on screen. The ECDIS will graphically identify points along the proposed route that are a danger to the vessel and return a textual list of the same hazards.

ECDIS safety check only verifies data along the user-defined corridor; the width of the corridor is set by the Cross Track Distance (XTD). The safety check will be performed against the largest scale information within the ECDIS system irrespective of the ECDIS display scale. Point features will only be identified as hazards if they fall within the safety zone being checked regardless of the size of the symbol displayed on screen and regardless of the actual extent of the physical feature it represents. Due to the compilation scale of the ENC there could be occasions where the charted point feature may not represent the full extent of the real-world feature. The Mariner must therefore ensure his safety corridor XTD is sufficiently wide enough to identify all navigational dangers along the intended route. Mariners are also required to conduct a thorough visual check of the intended route to complement the automated safety check.

The two following fictitious examples show how a hazardous point feature could be missed if the correct ENC scale charts are not loaded in the ECDIS and route XTD is not adequately set.

Example 1

In the first example (Figure 4), the charted position of the 'isolated danger' point feature representing the reef lies about 55m to the east of the planned route and falls within the route safety region. As this point lies within the route safety region set by the Mariner, the ECDIS will detect the reef as a danger close to the planned route and include it in the list of dangers for that leg of the route.

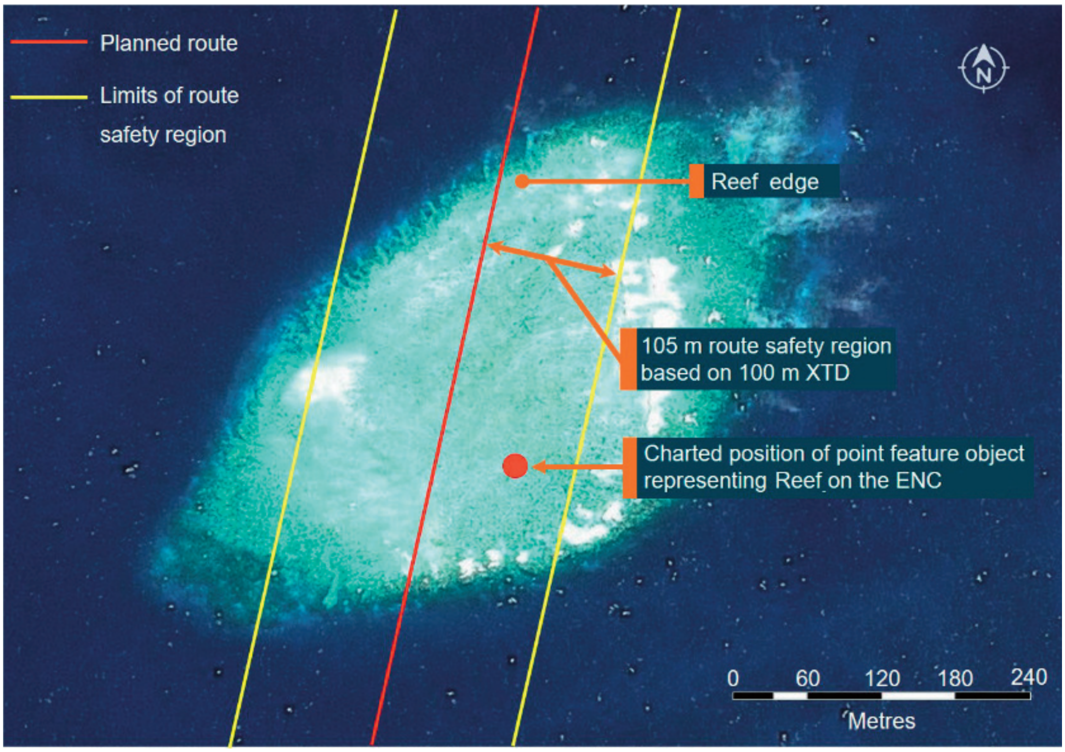


Figure 4: Planned route covers the position of the point symbo

Figure 4 shows the planned route and the ECDIS route safety region based on a 100m Cross Track Distance (XTD) near the point position used to represent the reef within the ENC. Note that the charted point position lies within the route safety region and will result in an ECDIS alert.

Source: DigitalGlobe, Esri, modified and annotated by the ATSB and the AHO.

Example 2:

In the second example (Figure 5), the planned route lies 55m further to the west. The charted position of the point feature now lies outside the ECDIS route safety zone set by the Mariner. In this case, the ECDIS will not detect the reef as a danger on or close to the planned route. However, the reef still clearly presents a danger to the ship.

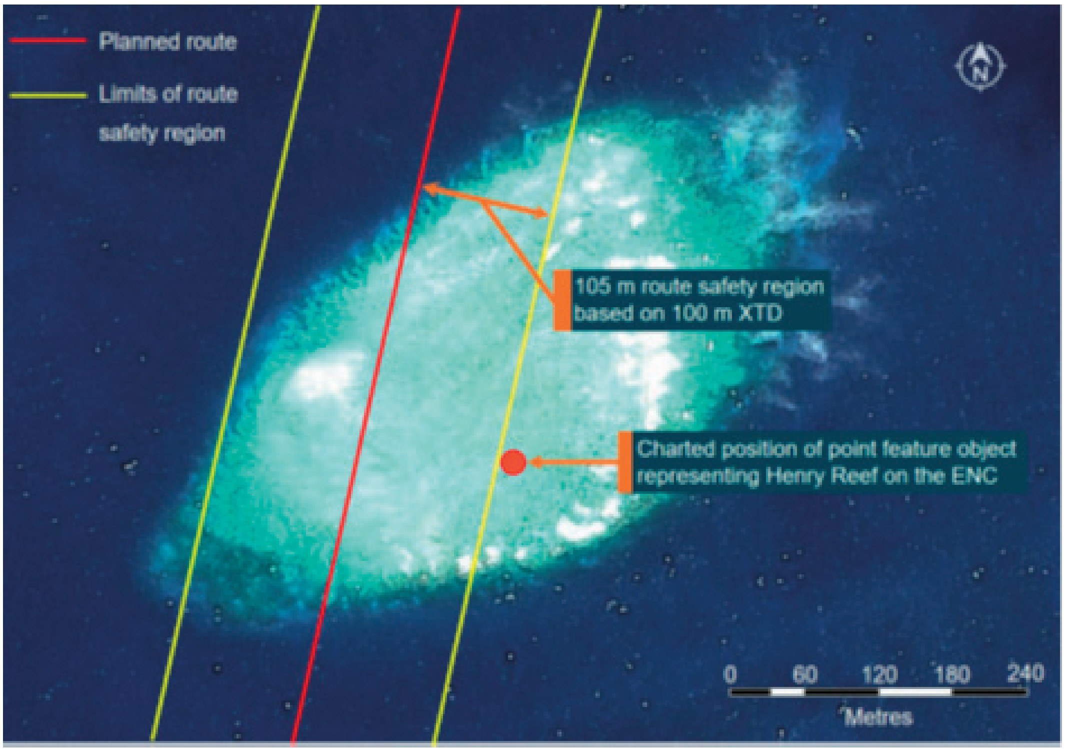


Figure 5: Planned route misses the position of the point symbol

Figure 5 shows a similar planned route and route safety region, 55m further west, near the same point position used to represent the reef within the ENC. The charted point position now lies outside the route safety region and therefore no longer results in an ECDIS alert. However the route still passes over the true reef extent.

Source: DigitalGlobe, Esri, modified and annotated by the ATSB and the AHO.

In this situation, if the vessel has not taken into account the possibility of isolated reefs within the region, and resultantly extended the XTD to at least account for the horizontal accuracy component of the underlying quality information (CATZOC), there is a possibility the danger could be missed during the visual inspection and the vessel could potentially run aground without the ECDIS indicating the danger on the planned route.

Given the size of the reef in the examples, it must be stressed that it would typically warrant capture by the cartographer as an area feature within an ENC compiled at the scale of the examples; and only at significantly smaller compilation scales would it be captured as a point feature.

A similar scenario and associated safety implications equally applies to the ECDIS look-ahead function and XTD once the ship is underway and monitoring along the planned route.

ENC over-scaling

A key difference to note between charted area features and point features on an ECDIS display is that area features change size in proportion to the scale at which the ENC is being viewed, whereas point feature size remains constant irrespective of display scale (see Figure 2); in other words they are not enlarged as viewing scale is increased.

Additionally, the size and shape of the point symbol does not necessarily represent the size or shape of the physical, real-world feature it is depicting.

Traditionally, nautical cartographers have sought to ensure that the symbol on the chart is larger than the real-world feature it represents when seen at the chart's compilation scale. Navigational purpose is also taken into consideration; a chart that is intended for coastal navigation, where it is not intended that the chart is to be used for close approach to isolated features, may also factor into the decision of the cartographer as to whether to depict a feature as an area or a point symbol on the chart. This practice remains true in the preparation of ENC, where the compilation scale defines the maximum intended viewing scale for that ENC in ECDIS.

However, when the ENC is viewed at scales progressively larger than the compilation scale, the intended relationship between the point symbol and the area feature it represents is broken; as the ENC is progressively 'over-scaled' on screen, the symbol represents a progressively smaller proportion of the real-world feature, such as a reef area, on the ECDIS display. This can lead to an incorrect assumption by the Mariner that they may go closer to the edge of the point symbol when the display is 'over-scaled'; this would be a dangerous assumption.

As a point feature, a reef is charted in a specific latitude/longitude position on the ENC, typically representing the centre of the area of the reef. Visually, this means that the symbol representing the reef will always be centred on this position (see Figure 1); and when viewed at the ENC compilation scale, or smaller, the symbol will typically cover the true extent of that reef. On the ECDIS display, the symbol always maintains an absolute size of 7mm in diameter regardless of the scale at which the ENC is viewed (see Figure 6). However, if the display scale has been over-scaled to twice the ENC compilation scale, a considerable extent of the reef (previously covered by the symbol), may now extend well beyond the symbol, without any indication of such in the ECDIS (see Figure 8).

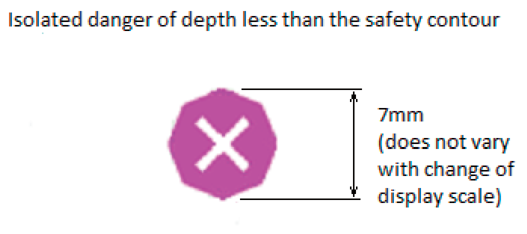


Figure 6: Isolated danger (point) symbol in ECDIS

Source: IHO.

The ECDIS has the functionality to allow ENCs to be displayed at scales larger than the original compilation scale. However, the ability to zoom in beyond the compilation scale (the maximum intended viewing scale) has introduced an inherent risk that is not present in paper charts. To minimize these risks, ECDIS includes indicators to alert when an ENC is being viewed beyond the maximum intended viewing scale.

1. Over-scale indication shown within the graphical user interface
2. Over-scale (jail bar) pattern

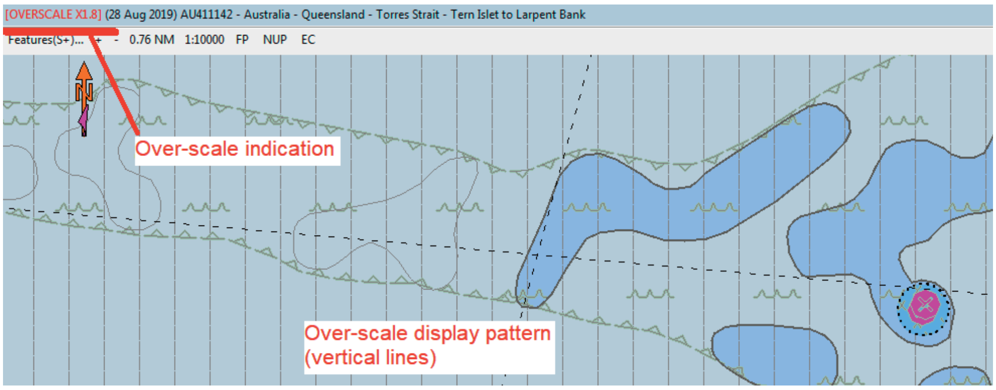


Figure 7: Over-scale indication and over-scale pattern on ECDIS

Source: AHO.

Z

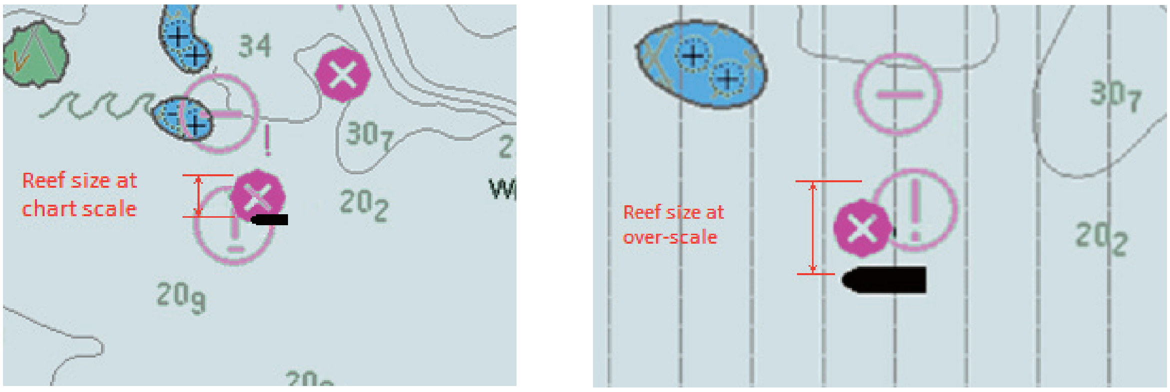


Figure 8: Over-scale indication and over-scale pattern on ECDIS

n the image on the left, shown at maximum intended viewing scale, a Mariner can immediately see that passing close to the charted isolated danger would be unwise. In contrast, in the image on the right, shown over-scaled, passing the same distance from the same isolated danger appears safe. Unfortunately, as the symbol has not been enlarged in proportion to the display scale, it no longer fully covers the reef, resulting in a hazardous navigation situation.

Source: AHO.

It is important to also note that the ECDIS will provide an indication if the ship's position is covered by an ENC at a larger scale than the current ENC being used in the ECDIS display.

Conclusions and recommendations

With many additional ENC tools capable of planning routes the Mariner must still be aware that only the ECDIS is certified for carrying out route planning and monitoring. To ensure safety and compliance it is imperative that all the appropriate scale ENCs are used in the ECDIS for adequate route planning and monitoring. The route must be automatically safety checked and a visual inspection performed at the largest scale possible, based on the available portfolio of ENCs, before the voyage commences. To ensure all dangers are identified by the ECDIS auto safety check function the Cross Track Distance must be appropriately set, taking into account factors such as the accuracy of the ship's positioning and navigation system; the bathymetric data quality information included in the ENCs (such as CATZOC); and the intended navigational purpose of the ENCs loaded into the ECDIS.

There is a common misconception by some Mariners that zooming in beyond the compilation scale of the ENC allows for greater accuracy – however, this is not the case. In reality zooming in beyond the intended maximum display scale of ENCs may be misleading and dangerous, particularly for 'isolated dangers of depth less than the safety depth'.

The risks associated with over-scaling the ENC within ECDIS are two-fold:

Firstly, the symbol selected by the cartographer to represent a real-world feature may no longer fully cover that feature.

Secondly, but most importantly, because the text and point symbols stay the same size within the over-scaled ENC, any sense of appropriate distance from a potential danger is no longer intuitive and can result in a false sense of safety that does not reflect reality.

Mariners are strongly advised not to zoom in ECDIS beyond the compilation scale to a point where the ECDIS over-scale indication or pattern are triggered.

Some ECDIS allow the operator to turn off over-scale warnings. This is not recommended under normal circumstances.

Familiarization with all the core functions of the ECDIS are mandatory requirements within STCW and are essential for safe navigation. Mariners must be familiar with the properties of the ECDIS; and develop a sufficient understanding of how and when the ECDIS indicates that ENC data is being displayed at an unsafe scale, so that the display settings can be adjusted accordingly.

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INFORMATION ON IHO STANDARDS RELATED TO ENC AND ECDIS

This document provides background information for Electronic Chart Display and Information System (ECDIS) users, port State control (PSC) inspectors and other stakeholders in ENC and ECDIS regarding the IHO standards that relate to the carriage and operation of ECDIS. The following topics are covered:

A list of the of the current IHO standards in force is available on the IHO website at:

https://iho.int/en/standards-in-force (English); and https://iho.int/fr/normes-en-vigueur (French).

Further iformation can be supplied on request. Enquiries should be directed to the IHO Secretariat at info@iho.int.

IHO Standards Background

The International Hydrographic Organization (IHO) is the intergovernmental organization responsible for developing international standards related to hydrographic services as defined in SOLAS regulation V/9. Under its remit, and in support of the relevant performance standards for ECDIS adopted by the International Maritime Organization (IMO), the IHO maintains the following set of standards related to ECDIS:

- S-57 - Transfer Standard for Digital Hydrographic Data (including the Product Specification for Electronic Navigational Chart (ENC);
- S-52 - Chart Content and Display Aspects of ECDIS;
- S-52 Annex A - ECDIS Presentation Library (Preslib);
- S-64 - Test Data Sets for ECDIS;
- S-58 - ENC Validation Checks;
- S-61 - Product Specification for Raster Navigational Chart (RNC);
- S-62 - Data Producer Codes;
- S-63 - Data Protection Scheme;
- S-65 - ENCs: Production, Maintenance and Distribution Guidance;
- S-11 Part A - Guidance for the Preparation and Maintenance of International (INT) Chart and ENC Schemes.

As a consequence of the investigations into the anomalous operation of some ECDIS, the IHO undertook in 2012 a review of its standards related to ECDIS. The review revealed that certain parts of the requirements of the IHO ECDIS-related standards had been interpreted and implemented in different ways by different manufacturers. The investigations made it clear that there were a number of improvements that should be made to reduce the risk of implementation irregularities in the future and improve the clarity of the standards. Feedback from ships at sea also indicated that there were a number of display enhancements that would significantly increase the usability of ENC in ECDIS.

This review led to the development of three new editions of the following IHO ECDIS related standards:

IHO S-52 Annex A ECDIS Presentation Library, Edition 4.0

This standard controls the graphical display of the ENC in ECDIS, from the symbols and line styles that must be used to depict features right through to the colours that govern the day, dusk and night modes. This standard has been extensively updated to address excessive alarms and other ECDIS related display anomalies. A summary of the main changes introduced in IHO ECDIS Presentation Library (PresLib) Edition 4.0 is included at Annex A of this document.

IHO S-63 Data Protection Scheme, Edition 1.2

This standard protects against data piracy by encrypting the ENC information. It also provides a mechanism for mariners to licence ENCs from data providers; and provides authentication assurance that the ENC data being loaded into the ECDIS has come from an approved source. It has been updated to include a new Annex specifying how to implement an ENC update status report.

IHO S-64 Test Data Sets for ECDIS, Edition 3.0

This standard contains sets of ENCs and RNCs designed specifically to support ECDIS manufacturers taking systems through the process of type approval against IEC Standard 61174. It has been updated with new test data sets to ensure the presentation of ENC features displayed in ECDIS is correct.

Regulations Related to ECDIS and ENC

SOLAS Chapter V Regulation 18

4. Systems and equipment installed prior to the adoption of performance standards by the Organization may subsequently be exempted from full compliance with such standards at the discretion of the Administration, having due regard to the recommended criteria adopted by the Organization. However, for an electronic chart display and information system (ECDIS) to be accepted as satisfying the chart carriage requirement of regulation 19.2.1.4, that system shall conform to the relevant performance standards not inferior to those adopted by the Organization in effect on the date of installation, or, for systems installed before 1 January 1999, not inferior to the performance standards adopted by the Organization on 23 November 1995 **.

** Recommendation on Performance Standards for Electronic Chart Display and Information Systems (ECDIS) (resolution A.817(19)).

SOLAS Chapter V Regulation 19

2. Shipborne navigational equipment and systems

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 electronic chart display and information system (ECDIS) is also accepted as meeting the chart carriage requirements of this subparagraph. Ships to which paragraph 2.10 applies shall comply with the carriage requirements for ECDIS detailed therein;

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 nautical 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).

SOLAS Chapter V Regulation 27

Nautical charts and nautical 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.

MSC.1/Circ.1503 (as amended) ECDIS – Guidance for Good Practice

The mandatory carriage of ECDIS, as required by SOLAS regulation V/19.2.10, was subject to a staged entry into force between 1 July 2012 and 1 July 2018. As per SOLAS regulations V/18 and V/19, for a ship to use ECDIS to meet the chart carriage requirements of SOLAS, the ECDIS equipment must conform to the relevant IMO performance standards. ECDIS units on board are required to comply with one of two performance standards (either IMO resolution A.817(19), as amended; or resolution MSC.232(82)), depending on the date of their installation. Essentially, where an ECDIS is being used to meet the chart carriage requirements of SOLAS, it must:

i. be type-approved;
ii. use up to date electronic navigational charts (ENC);
iii. be maintained so as to be compatible with the latest applicable International Hydrographic Organization (IHO) standards; and
iv. have adequate, independent back-up arrangements in place.

IMO MSC.1/Circ.1503 (as amended) states, ‘ECDIS that is not updated to the latest version of the IHO Standards may not meet the chart carriage requirements as set out in SOLAS regulation V/19.2.1.4’.

The changes introduced in the latest versions of the IHO standards will assist port State control (PSC) inspectors in determining if a vessel is complying with the regulations from SOLAS Chapter V. The IHO maintains a list of the current IHO standards in force on its website – https://iho.int/en/standards-in-force (English); and https://iho.int/fr/normes-en-vigueur (French).

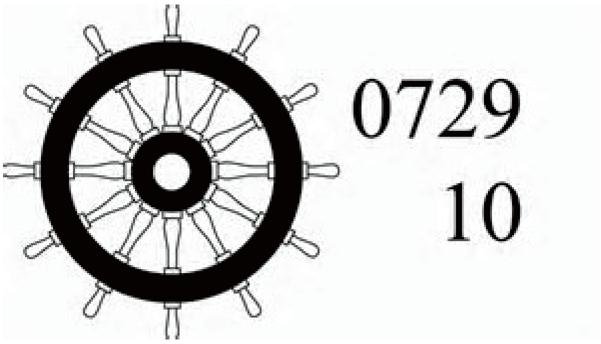
i) be type-approved

To ensure ECDIS comply with the requirements in the relevant IMO performance standards they are tested against these requirements by approved Notified Bodies. The current testing standard for ECDIS is maintained by the International Electrotechnical Commission (IEC) and is IEC 61174 Edition 4.0 – *Maritime navigation and radiocommunication equipment and systems — Electronic chart display and information system (ECDIS) Operational and performance requirements, methods of testing and required test results*, published in August 2015. All ECDIS that are type approved according to IEC 61174 Edition 4.0 must comply with the display requirements in IHO S-52 Presentation Library Edition 4.0 and IHO S-63 Data Protection Scheme, Edition 1.2.

ECDIS type approved according to the previous editions of IEC 61174 need to be upgraded to the new IHO Presentation Library Edition 4.0. However there is no requirement that these ECDIS be updated to IHO S-63 Data Protection Scheme, Edition 1.2. The impact of this is that:

- Older ECDIS not yet updated to Presentation Library Edition 4.0 will not benefit from the significant changes introduced in Presentation Library Edition 4.0 and may not meet the chart carriage requirements as set out in SOLAS regulation V/19.2.1.4.
- Older ECDIS updated to Presentation Library Edition 4.0 but still using IHO S-63 Edition 1.1 will not be able to display an ENC Status Report from within the ECDIS.

All ECDIS approved within the European Union under the Marine Equipment Directive (MED) are given a Wheel Mark which is affixed to the equipment.



The first number denotes the Notified Body that awarded the type approval; the second number denotes the year the equipment passed approval.

ii) use up to date electronic navigational charts (ENC)

Hydrographic Authorities are required to keep nautical charts up to date to include all information considered to be relevant to safety of navigation (including temporary or preliminary information)[1]; and as such regularly issue updates to their ENCs. For an ECDIS to be used for navigation it must have the correct up to date ENCs for the intended voyage. Therefore the only indicator that the ENC data in the ECDIS is up to date is that the latest ENC update available for an ENC as issued by the Hydrographic Authority has been applied to the SENC.

There are currently two chart distribution services an international mariner can sign up to for delivery of ENCs (noting there are also several national distribution services for mariners operating exclusively in national waters).

1. Standard subscription - ENC permits are purchased for a known operating area for a fixed periods of time (3 to 12 months). This enables the decryption of these ENCs in ECDIS and enables their use for planning and navigation.
2. Pay As You Sail (PAYS) – Mariners pay a minimal planning fee for upfront use of the entire global ENC data set. A tracking service is fitted to the vessel and as they navigate across ENCs they are charged accordingly. PAYS services can give instant access to most ENC chart across the globe.

To facilitate PSC inspections and to assist mariners in satisfying themselves that their ENC data is "up to date" S-63 was updated to Edition 1.2, adding an additional annex covering the ENC Status Report. Only ECDIS type approved according to Edition 4.0 of IEC 61174 will be capable of displaying the report. The report is a concise and standardized format designed for two individual use cases:

a) To ensure that all ENC cells loaded into the ECDIS SENC are up to date for the next leg of a particular route; and

b) To ensure that all ENCs loaded into the SENC are up to date.

Vessel Name:	HMS Goteborg
Identifier:	IMO 4653321
ENC Update Reference Date:	16 May 2013 : WK24/2013
Date of Report:	1 Jun 2013
Content:	Filtered for Route Plan "Goteborg – Kiel"
Start WP:	Goteborg [57.7N,11.966667E]
End WP:	Kiel [54.333742N,10.159607E]

Chart Status Summary:

Chart Status:	**Count**
Total:	50
Up to Date	38/50
Not Up to Date	10/50
Withdrawn	2/50
Unknown	0/50

Data Server: GB				
Cell Name	**Edition**	**Update**	**Issue Date**	**Status**
DE316001	5	1	13 Mar 2013	Not Up to Date
DE416010	1	1	12 Apr 2012	Not Up to Date
DE416020	6	2	11 May 2012	Not Up to Date
DE416021	8	3	10 May 2012	Not Up to Date

Figure 1 - Example ENC Status Report

[1] Refer to IHO Publication S-4 clauses B-600, B-601.7, B-633.1 and B-634.1

If an inspection is carried out on a new ECDIS with this functionality it is important to understand how the ENC Update Status Report works and what the returned values mean.

The top of the report will list vessel name, IMO number and other important data. For the report to work correctly the ECDIS requires a reference date; this enables the system to calculate if an ENC cell has been updated. The date is taken from the last S-63 SERIAL.ENC file installed in the ECDIS which is delivered as part of the ENC exchange set from a data provider.

The data content of each of the header fields is defined in the table below:

Name	Data Type	Description
1. Vessel Name	Text	The name of the vessel as recorded within the ECDIS.
2. Identifier	Text	A unique identifier, the MMSI or vessel IMO number.
3. ENC Update reference date	Date	The data used as the reference for the status of each of the cells. This is the date stamp of the last data server's service media used to update the SENC. The date is taken from the S-63 SERIAL.ENC, expressed both in standard notation "NN MMM YYYY" and week number as defined in S-63.
4. Date of report	Date	The date the report was run.
5. Content	Text	This field denotes the content type of the report. There are two possibilities: "Filtered for Route Plan XXX to YYY" where XXX and YYY are the textual names of the point of origin and destination on the chosen route. Full SENC contents.
6. Start WP	Text	This field is only present if the report is filtered for a route. It should comprise the textual name of the starting waypoint of the route (if one exists) and the lat/lon coordinates of the waypoint. There is no fixed form that the coordinates should take.
7. End WP	Text	This field is only present if the report is filtered for a route. It should comprise the textual name of the last waypoint of the route (if one exists) and its lat/lon coordinates. There is no fixed form that the coordinates should take.

All the cells along an intended route are checked against the last ENC update reference date within the ECDIS. The ENC cells are then given a status; the description of each status type is given below:

ENC Update 'Status'	Description
Up to date	The ECDIS has all the latest update and/or new edition information for the cell installed as defined by the latest PRODUCTS.TXT data. NOTE: The ENC Update reference date must be within the last four weeks from the time of the report execution or the cell shall be displayed as "Not up to date" regardless of its status as defined by the PRODUCTS.TXT data.
Not Up to date	The ECDIS does NOT have installed the latest update and/or new edition for the cell. Again, the reference point for what should be installed is defined by the ENC Update reference date. NOTE: If the reference date is older than four weeks then cells shall be displayed as "not up to date" by definition.
Withdrawn	The number of cells which have been withdrawn by the data server or cancelled but which are still available within the ECDIS.
Unknown	Cells for which a status cannot be determined for any reason. If cells from a dataset with a "PARTIAL" PRODUCTS.TXT file are loaded then all cells in a data server's service but not included in the partial PRODUCTS.TXT shall be deemed to be "Unknown" as no definitive information on them can be determined. A "FULL" PRODUCTS.TXT content is required to specify the status of all cells in a data server's service.

iii) be maintained so as to be compatible with the latest applicable International Hydrographic Organization (IHO) standards

All ECDIS have a function to display the current edition of the IHO Presentation Library being used to display the ENCs. Clause 19.1 of IHO ECDIS Presentation Library Edition 4.0 states: 'The edition number of the PresLib installed must be available to the Mariner on request'. This requirement is therefore tested for in ECDIS type approval – IEC 61174 Edition 4, clause 5.5.1.

For mariners that have upgraded their ECDIS to IHO S-52 Presentation Library Edition 4.0 and require a method to check that their ECDIS is capable of displaying the new symbols introduced in IHO S-52 Presentation Library Edition 4.0, the recommended course of action is to use ECDIS Chart 1.

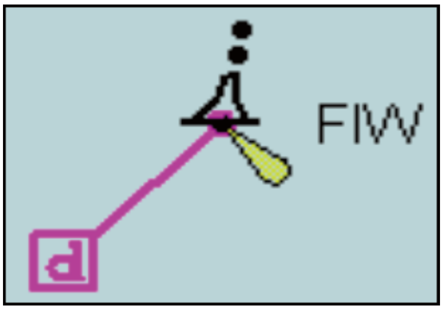
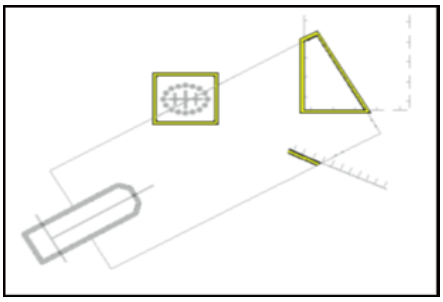
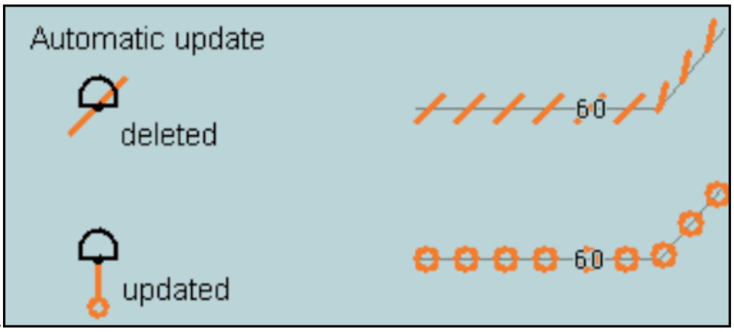
	Magenta 'd' symbol used on ENC features that have a date dependent attribute populated.
	Indication highlight symbology for objects that pose a danger to the vessel.
	Automatic update symbology for identifying where changes to the ENCs have occurred.

Figure 2 - New ECDIS symbols introduced in IHO S-52 Presentation Library Edition 4.0

iv) have adequate, independent back-up arrangements in place.

Details of a ship's navigational systems and equipment must be recorded in the "Record of Equipment". The means of complying with SOLAS regulation V/19 needs to be indicated (that is, paper charts and/or ECDIS) in the relevant "Record of Equipment". Declaring ECDIS in the ship's "Record of Equipment" makes ECDIS a surveyable item under SOLAS regulation V/19.

The IMO performance standards for ECDIS require that adequate back-up arrangements should be provided to ensure safe navigation, in case of an ECDIS failure. There are various ways for a vessel to achieve this either using:

- Paper charts;
- A second independent IMO compliant ECDIS unit connected to a separate power supply; or
- Chart radar unit connected to a separate power supply.

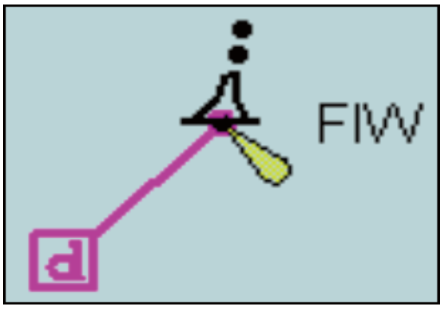
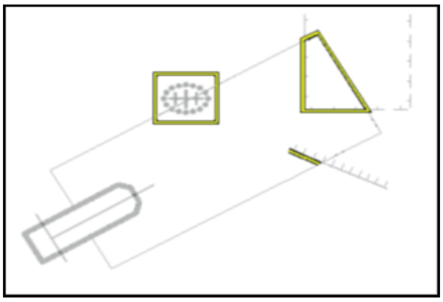
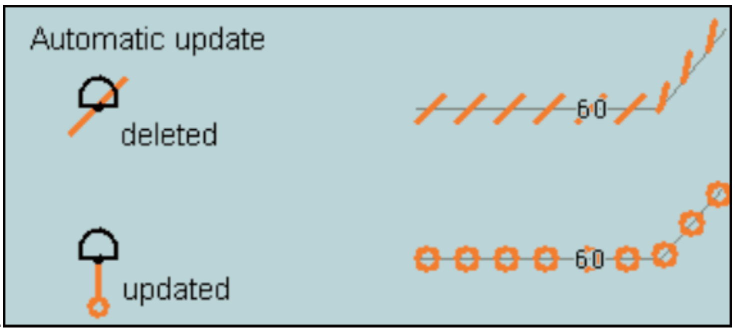
Where paper charts are being used as a back-up to a single ECDIS using ENCs, they must be kept up-to-date with the latest Notice to Mariner corrections. An Appropriate Portfolio of Paper Charts (APC) will be required for the whole of the intended voyage where this back-up option is used. The information provided by coastal States regarding their recommendations for the paper charts to be carried in the waters under their jurisdiction may be found by visiting the relevant national hydrographic authority's web site, as listed in IHO Publication P-5, available at https://iho.int/uploads/user/pubs/periodical/P5YEARBOOK_ANNUAIRE.pdf.

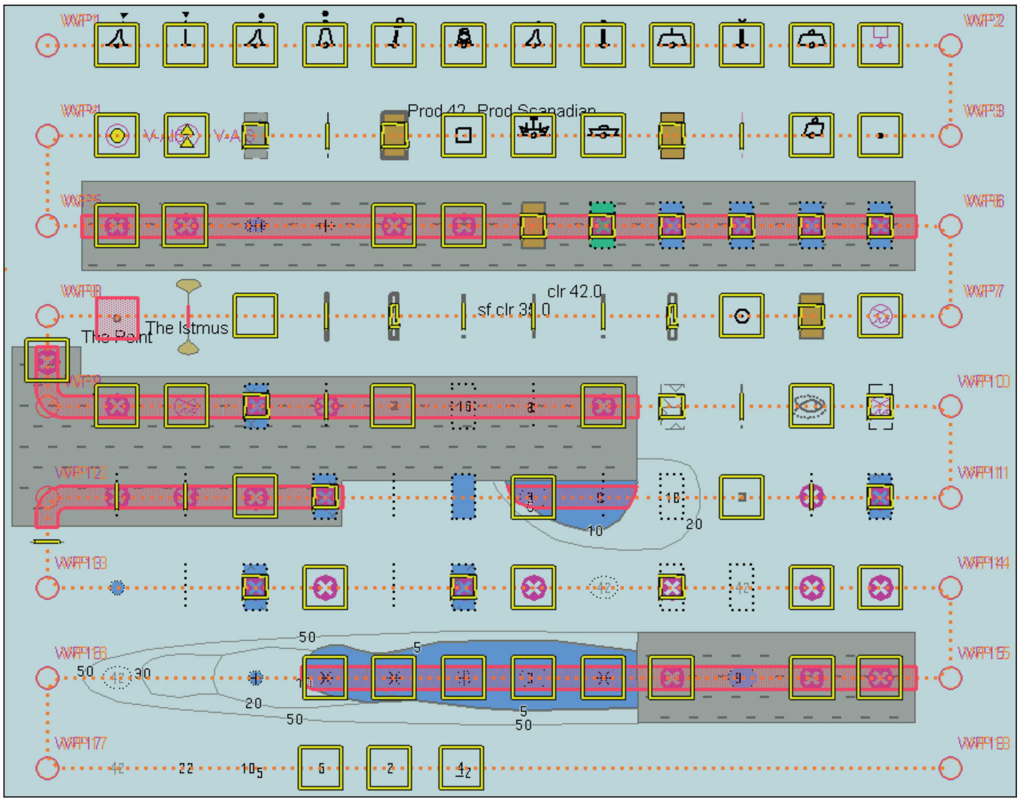
ANNEX A
IHO S-52 ECDIS PRESENTATION LIBRARY EDITION 4.0
MAIN CHANGES

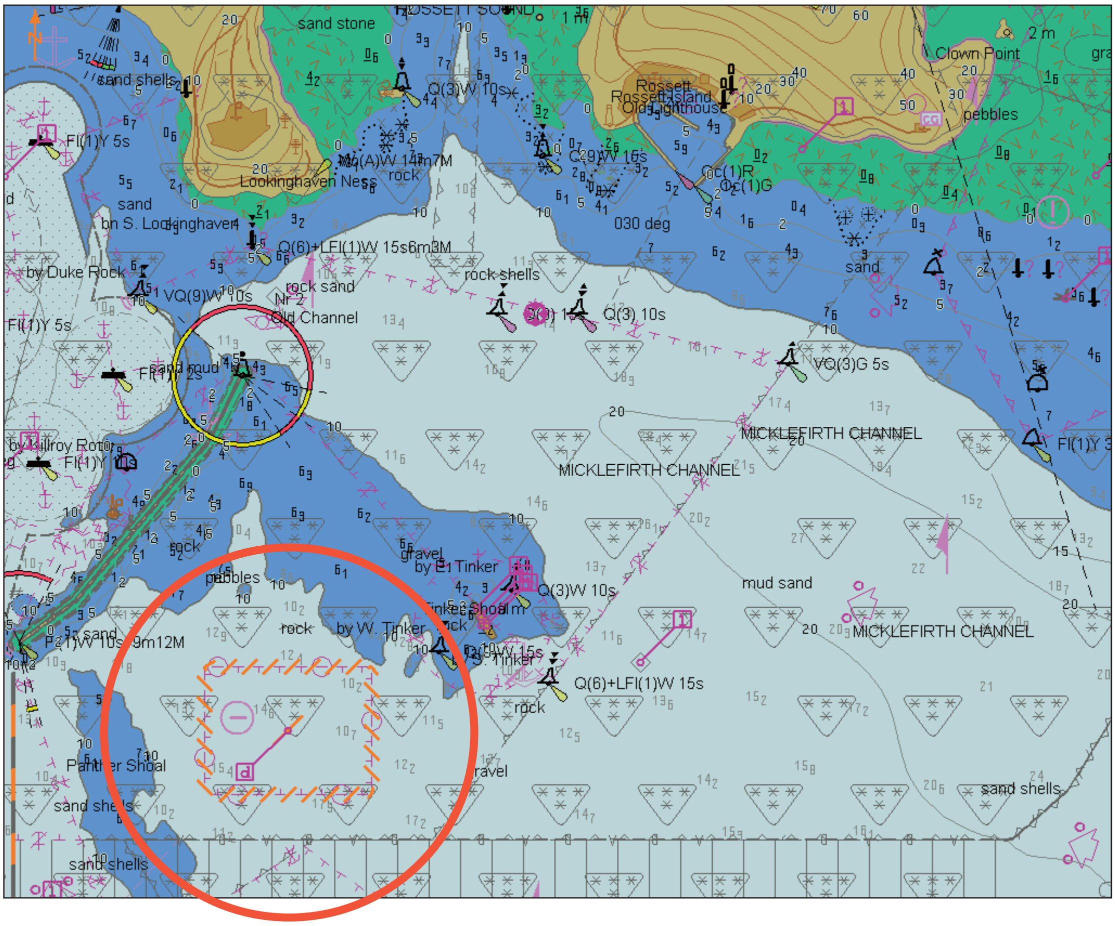
IHO S-52 Changes	Mariner's Benefits
A new section "Detection and Notification of Navigational Hazard" has been added. For each ENC feature and its associated attributes this defines the priority of the alert to be raised when a navigational hazard is detected.	Ensures all ECDIS raise the required alerts in a consistent manner, reducing training needs and improving safety at sea. Reduces the number of alarms raised as a result of ECDIS safety checking.
A new section "Detection of Areas, for which Special Conditions Exist" has been added. Lists the ENC features and attributes that will raise an indication or alert in the ECDIS as defined by the mariner	Ensures all ECDIS raise the required alerts in a consistent manner, reducing training needs and improving safety at sea. Reduces the number of alarms raised as a result of ECDIS safety checking.
Detecting the Safety Contour: The IMO ECDIS Performance Standard (PS) states that rocks, wrecks and obstruction detected inside the safety contour should result in an indication on the ECDIS. The previous edition of S-52 included rocks, wrecks and obstructions to the detection of the safety contour, resulting in alarms, as opposed to indications, being raised. They have been moved to "Detection and Notification of Navigational Hazards".	Reduces the number of alarms on ECDIS, whilst ensuring that the mariner remains aware of dangers as rocks, wrecks and obstructions will still be detected if they meet the "Detection and Notification of Navigational Hazards" criteria.
Added a new symbol 'Indication Highlight' – designed for warning and caution conditions that require an indication highlight on the ENC	Clear and unambiguous presentation of features that require an indication highlight.
New standardized symbols have been added to identify where automatic ENC updates have been applied.	Ensures the mariner is aware of updates that have been applied automatically to their ENCs
New symbol to indicate where in the ENC features with temporal attributes are located.	Will allow mariners to quickly identify where features that have temporal attributes are located, such as seasonal buoys, traffic separation schemes etc.
A means for the mariner to insert a date or date range within the ECDIS to display date dependent features.	Will allow the mariner the ability to plan and check routes, viewing the conditions they will encounter on a given date or time period in the future
Ability to turn isolated dangers in shallow water on/off.	In certain circumstances mariners must navigate across the safety contour, this change allows the mariner the flexibility to navigate in shoal areas with or without the isolated danger symbol displaying on the ENC
Mandatory selector for the display of the shallow water pattern.	Important feature in ECDIS as it becomes increasingly difficult to detect the changes in the ENC depth shades during night navigation.
Added guidance on the implementation of the optional "hover-over" function available for a limited number of ENC features	If provided, the hover-over function speeds up the process of ENC enquiry by the mariner. The new guidance ensures that the hover-over function does not result in the ENC presentation becoming obscured.
Display of complete tidal stream panel in ECDIS pick report.	Provides the mariner with tidal data in a form that is similar to the paper chart equivalent

IHO S-52 Changes	Mariner's Benefits
Changes to S-52 display provisions: Anchorage area – display of name in ENC; Fairway – display of name in ENC; Nautical publication – new visible presentation for the meta feature nautical publication.	Allows the mariner to navigate to an anchorage without the need to repeatedly interrogate each area on the ENC by: 1. Presenting the name of fairway on the ENC for quick identification of location; 2. Presenting a graphical indication on the ENC to give mariners the ability to easily select the nautical publication feature using the pick report
Standardization of the ECDIS pick report.	Ensures all ECDIS present pick report information in a consistent manner, reducing training needs and improving safety at sea.
The viewing groups may be used by the mariner to customise the ENC information presented on the ECDIS display. The names of these viewing groups have been standardized.	Ensures all ECDIS use viewing group nomenclature in a consistent manner, reducing training needs and improving safety at sea.

NEW SYMBOLS

	Magenta 'd' symbol used on ENC features that have a date dependent attribute populated.
	Indication highlight symbology for objects that pose a danger to the vessel.
	Automatic update symbology for identifying where changes to the ENCs have occurred.


WP1
WP2
WP4
Prod 42
Prod Scanadian
WP3
WP5
WP6
WP8
The Point
The Istmus
clr 42.0
sf clr 35.0
WP7
WP9
WP10
WP12
WP11
WP13
WP14
WP16
WP15
WP17
WP18


ROSSETT SOUND
sand stone
sand shells
Fl(1)Y 5s
Lookinghaven Ness
Mo(A)W 14m7M
rock
sand
bn S. Lookinghaven
Q(6)+LFl(1)W 15s6m3M
by Duke Rock
VQ(9)W 10s
rock sand
Nr 2
Old Channel
rock shells
Q(3) 10s
Q(3)W 10s
Rossett
Rossett Island
Old Lighthouse
Q(9)W 15s
Oc(1)R
Oc(1)G
030 deg
Clown Point
pebbles
2 m
VQ(3)G 5s
MICKLEFIRTH CHANNEL
MICKLEFIRTH CHANNEL
by Killroy Rock
Fl(1)Y
gravel
by E. Tinker
Tinker Shoal
Q(3)W 10s
mud sand
MICKLEFIRTH CHANNEL
by W. Tinker
Q(6)+LFl(1)W 15s
Fl(1)W 10s 9m12M
Panther Shoal
sand shells
sand shells

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INTERNATIONAL HYDROGRAPHIC ORGANIZATION

MARINERS' GUIDE TO ACCURACY OF DEPTH INFORMATION IN ELECTRONIC NAVIGATIONAL CHARTS (ENC)

IHO Publication S-67 – Edition 1.0.0

(Publication date: September 2020)

IHO

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Hydrographic
Organization

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Document Control

Changes to this Product Specification are coordinated by the IHO Data Quality Working Group (DQWG) which is a Working Group of the IHO Hydrographic Services and Standards Committee (HSSC). New editions will be made available via the IHO web site.

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0.4	April 2017	DQWG	Draft document for discussion (DQWG-12)
0.5	August 2017	DQWG	Review by correspondence
0.6	July 2018	DQWG	Review by correspondence
0.7	September 2018	DQWG	Review results included
0.8	May 2019	DQWG	Australian comments included
0.9	February 2020	DQWG	Draft for WG approval
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1.0.0	July 2020	DQWG	Final draft.
1.0.0	September 2020	DQWG	Published Edition 1.0.0

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TABLE OF CONTENTS

Preface

IHO publication S-67 "Mariners Guide to Accuracy of Depth Information in ENC" is a guide to navigators, and navigator training organizations, on the degree of confidence they should have in the adequacy and accuracy of charted depths and their positions in an Electronic Navigational Chart.

This document is laid out, as far as possible, along the lines of the IHO Publications S-4 – "Regulations of the IHO for International (INT) Charts and Chart Specifications of the IHO"; S-57 – "IHO Transfer Standard for Digital Hydrographic Data"; and S-52 – "Specifications for Chart Content and Display Aspects of ECDIS".

The intended readers for this document are navigators on coastal or international voyages; and organizations training navigators for these voyages.

This document is supplementary to IHO Publication S-66 – "Facts about Electronic Charts and Carriage Requirements"; and the already existing IHO Standards mentioned above, so as to provide a more in-depth knowledge as to how a navigator should interpret the depth information presented to them by an Electronic Chart Display and Information System (ECDIS). Readers of this document should also consult guidance regarding national policies on the depiction of depth accuracy information in ENCs, such as Mariners' Handbook and national hydrographic authority web sites, where they exists.

The IHO acknowledges the valuable contribution to the development of this document by various stakeholders, in particular Intertanko and CSmart/Carnival.

1 Introduction

The primary purpose of nautical charts is to provide the information required to enable the mariner to plan and execute safe navigation.[1] The mariner has a need for appropriate, relevant, accurate and unambiguous information.

Most Hydrographic Offices have an obligation to provide nautical chart cover of their national waters to such an extent, and on such scales, as to permit safe navigation for all classes of vessel, from the smallest to the largest, throughout coastal waters, including major ports visited by the largest vessels and minor arms of the sea of purely local interest. In this, the best-known sense, nautical charts are navigational tools.[2]

National nautical chart series are usually the largest scale publications available showing the detailed configuration of the seabed offshore. In this respect, Hydrographic Offices have a de facto responsibility for their national waters similar to that of topographic mapping agencies for land areas. Such information about the shape of the seabed is required by a variety of national users other than navigators. For example, construction engineers concerned with offshore developments; dredging contractors; oceanographers; defence departments; and coastal zone managers.[3]

The combined effect of the two requirements has caused national chart series to cover national waters in great detail, reflected by small and medium scale charts to provide an overview, general picture and coastal image; and large scale charts to provide information for harbour approach, harbour and berthing. Hydrographic Offices supply Electronic Navigational Charts (ENCs) with the intended usage of the Chart aligned to so-called Usage Bands (or Navigational Purposes). Their values are:

1. Overview
2. General
3. Coastal
4. Approach
5. Harbour
6. Berthing

The mariner requires ENCs to be consistent throughout the Usage Bands, at least for essential data content; this is called ‘vertical consistency’. At smaller scales, details must be generalized, with only a selection of the available source data (including soundings) being portrayed, so that the information which is included in the ENC is presented clearly. Any sounding on the smallest scale chart will also be present on the largest scale.[4]

A chart presents an image of the real world to the mariner. The depth information in a chart is compiled from various sources, each having their own adequacy and accuracy. Given this, an obvious question arises: How can the mariner distinguish, when using an ECDIS, what the adequacy and accuracy of the depth information is for the planning and executing of a voyage?

1.1 Abbreviations

CATZOC	Category of Zone of Confidence in Data[5]
ECDIS	Electronic Chart Display and Information System
ENC	Electronic Navigational Chart
HO	Hydrographic Office
m	Metre
NM	Nautical Mile
ZOC	Zone of Confidence

2 Executive summary and recommendations

Accuracy of depth Information in an ENC can be visualized by showing the Zones of Confidence (ZOC) areas. A ZOC area is a generalized picture of the quality of charted depth information for that area. The quality of the hydrographic source data is assessed according to six categories (CATZOC): Five quality categories for assessed data (A1, A2, B, C and D); and a sixth category (U) for data which has not been assessed. The assessment of hydrographic data quality and classification into zones by Hydrographic Offices is based on a combination of:

- Depth accuracy;
- Position accuracy; and
- Seafloor coverage.

For ease of reading, this can be interpreted as follows:

- High accuracy depth information (ZOC A1 and A2), shown as 5 stars or more.
- Medium accuracy depth information (ZOC B), shown as 4 stars.
- Poor accuracy depth information (ZOC C, D and U), shown as 3 stars or less; or letter U.

[1] Adapted from S-4 clause B-100.4
[2] Adapted from S-4 clause A-102.1
[3] Adapted from S-4 clause A-102.1B
[4] Adapted from S-4 clause B-100.5
[5] S-57 Appendix A, Chapter 2 – page 2.106

ZOC can be visualized in an ECDIS by activating the ECDIS "Accuracy" selector. The following recommendations are made to the mariner:

- When planning a new voyage, ZOCs should be visualized as an overall check of the quality of the area the vessel is going to transit.
- When changing the planned route whilst en-route, the ZOCs should be visualized as an overall check of the quality of the area the vessel is going to transit.
- When route planning in areas with ZOC A1 and A2, the mariner should consider that isolated dangers and shallow soundings could be up to 20 metres from their charted position and at least 0.5-1 metre shoaler/deeper than their charted depth.
- When route planning in areas with ZOC B, the mariner should consider that isolated dangers and shallow soundings could be up to 50 metres from their charted position and at least 1 metre shoaler/deeper than their charted depth.
- When route planning in areas with ZOC C, D and U, the mariner should consider that isolated dangers and shallow soundings could be up to 500 metres from their charted position and at least 2 metres shoaler/deeper than their charted depth.
- The mariner should take note of the accuracy of the depth areas the vessel is planning to transit and take appropriate caution by applying appropriate safety margins, especially in situations where under keel clearance is critical and/or in areas of continual and rapid change.
- The mariner should take the horizontal accuracy as defined by the CATZOC for the area into consideration when setting cross track distance for the automatic route check function performed during the voyage planning.
- In ZOC C, D and U the mariner is advised to take caution as charted depths may in reality be significantly shallower. It is very likely that some significant seafloor features dangerous to the safety of navigation (rocks, coral reefs, wrecks, submerged obstructions) have not been identified, and do not appear in the chart.
- By using a Pick Report in ECDIS, the mariner can read additional quality information on isolated dangers to the safety of navigation and/or survey reliability, if these have been included in the ENC. Otherwise the mariner should assume that the isolated danger may in reality be out of position and/or be shallower as indicated by the CATZOC.
- The mariner must ensure to have the full portfolio of ENCs available at the appropriate chart scales suitable for the voyage being undertaken, as ECDIS in-built safety functions use the data encoded in the largest scale product available in the system (irrespective of it being displayed or not) to trigger alarms. ECDIS does allow the mariner to over-scale, however this will give a false sense of security of the accuracy of isolated dangers if CATZOCs are not checked; and their extent (see Annex B). Over-scaling the ECDIS display is not recommended under normal circumstances; as a consequence the over-scale indicator in the ECDIS should be heeded.
- Areas of continual and rapid change occur in many tidal rivers and estuaries; over bars in the approaches to some ports; and over some off-lying banks. A limitation of the CATZOC system is the lack of information about when a survey was conducted, or whether the seabed is stable; noting however that the date that a survey was conducted in an area may be available in the ENC through an ECDIS Pick Report. It is therefore considered important for mariners to note areas of sand-waves; dates within dredged channels; and any other notes advising that channels may have changed or are subject to change.

Put in simple terms, mariners should be able to navigate with confidence in areas with ZOC A1 and A2 classifications. It is also unlikely that uncharted dangers affecting surface navigation exist in ZOC B areas. In ZOC C areas mariners should exercise caution since hazardous uncharted features may be expected, particularly in or near reef and rocky areas, or areas of mobile seabed. A very high degree of caution is required for areas assessed as ZOC D, as these contain either very sparse data or may not have been surveyed at all. Finally, it is good practice for mariners to treat ZOC U areas with the same degree of caution as ZOC D areas.

Within ports, the Pilot or Harbour Master may advise that higher accuracy surveys have been conducted that allow for smaller under-keel clearances (subject to tides, weather, speed, and manoeuvring margins). In the absence of this advice, smaller under-keel safety margins should not be assumed.

In coastal shipping areas the most common assessments likely to be encountered are:

- ZOC B – around 40% of the world's coastal waters;
- ZOC C – around 30% of the world's coastal waters;
- ZOC D – around 10% of the world's coastal waters; and
- ZOC U – around 15% of the world's coastal waters.

While these percentages may vary from place to place, the key point to note is that the standards of surveying in ports are only very rarely encountered outside those ports. Ships may therefore be at greater risk away from ports, even though depths may be deeper. The risk will decrease with increasing under keel clearance (depths greater than 100 metres); and depth areas deeper than 200 metres are generally considered safe for surface navigation. An understanding of how much confidence can be placed in the depth information in an ENC is therefore most important.

Accuracy of depth information in paper charts

Charts provide information to guide navigators, and those planning 'navigational operations' (including the planning of new routes and official routeing measures), on the degree of confidence they should have in the adequacy and accuracy of charted depths and their positions. This is portrayed on paper charts as a graphic with accompanying text in what is known as a Source Diagram. This diagram provides information about source surveys from which the mariner can deduce the degree of confidence in charted depth information. The diagram provides an indication of:

- The adequacy of the equipment used;
- The thoroughness of examinations of dangers at particular depths (based on the maximum draught of vessels afloat at that date); and
- The likelihood of changes in depths, particularly in areas of mobile or unstable seabed or coral growth.

The date of the edition of a published paper chart can be misleading (as the source data may be much older) but may have some value.[6]

The type of survey should be stated on conventional paper chart Source Diagrams (the terms being translated as necessary):

- 'Survey' implies a regular, controlled or systematic hydrographic survey of any date.
- 'Sketch survey' or 'Reconnaissance survey' implies that there is a significant risk of undetected dangers, even if the 'survey' is of recent date.
- 'Passage soundings' implies soundings acquired on an uncoordinated basis over a period of years.
- Qualifying comments, for example: '(leadline)'; '(no sonar)'; and '(multibeam)', may be added after the type of survey where the date does not give sufficient indication of the survey methods.
- Where a charted survey is supplemented by occasional soundings from older or later sources, only the main survey should normally be listed.[7]

Areas of continual and rapid change occur in many tidal rivers and estuaries; over bars in the approaches to some ports; and over some off-lying banks.[8]

In most areas which have not been wire-swept or full seafloor search has not been achieved, there is a possibility that depths somewhat shoaler than those charted may exist. Navigators allow for this and other uncertainties by applying safety margins. Inadequately surveyed areas may be defined as those where bathymetry is based on older leadline surveys or other surveys which are either open in nature (for example reconnaissance surveys), or are not hydrographic surveys (for example seismic surveys). These types of surveys are inadequate for identifying all shoals that may exist between lines of soundings, or may not be 'shoal-biased' in their selection of recorded depths.[9]

The details and interpretations of published Source Diagrams often vary widely between nations. The variations in method, detail and interpretation render this type of quality information unsuitable for use in an electronic navigation system such as ECDIS, as it prevents use of automated checking routines to look along a planned route to confirm suitability.

When making the transition from paper chart to the ENC, the International Hydrographic Organization developed and published the concept of Zones of Confidence areas in their Publication S-57 – "IHO Transfer Standard for Digital Hydrographic Data". It should be noted that some Hydrographic Offices have replaced paper chart Source Diagrams with "Zone of Confidence (ZOC)" diagrams to be consistent with their ENC portfolio.

4 Accuracy of depth information in Electronic Navigational Charts

Depth accuracy in ENCs may be described in three ways:

1. Generalized information through a Zone of Confidence (ZOC) indication (mandatory);
2. Quality descriptions of individual objects dangerous to safe navigation (similar to labelling of individual features as "*PA*" or "*PD*" on paper charts) (optional); and
3. Reliability of a survey (optional).

NOTE: The optional methods listed in (2) and (3) are generally only viewable in ECDIS by utilizing the ECDIS Pick Report functionality (see clauses 4.2 and 4.3).

4.1 Generalized information

The quality of the bathymetric data charted on the ENC is assessed according to six categories (CATZOC or ZOC): five quality categories for assessed data (A1, A2, B, C and D) and a sixth category (U) for data which has not been assessed[10] (see Table 4-1 below). The CATZOC is an attribute included in the S-57 object class M_QUAL (Quality of Data). CATZOC indication covers all areas of the ENC that contain bathymetry; never overlap; and have no gaps between them. The assessment of bathymetric data quality and classification into zones is based on a combination of:

- Position accuracy;
- Depth accuracy; and
- Seafloor coverage.

[6] Adapted from S-4 clause B-294.1
[7] Adapted from S-4 clause B-295.2
[8] Adapted from S-4 clause B-416
[9] Adapted from S-4 clause B-417

Table 4-1 –ZOC Categories

ZOC	Position accuracy	Depth accuracy	Seafloor coverage
A1	± 5 m + 5% depth	0.50 m + 1% depth	Full area search undertaken. Significant seafloor features detected and depths measured.
A2	± 20 m	1.00 m + 2% depth	Full area search undertaken. Significant seafloor features detected and depths measured.
B	± 50 m	1.00 m + 2% depth	Full area search not achieved; uncharted features hazardous surface navigation are not expected but may exist.
C	± 500 m	2.00 m + 5% depth	Full area search not achieved, depth anomalies may be expected.
D	Worse than ZOC C	Worse than ZOC C	Full area search not achieved, large depth anomalies may be expected.
U	Unassessed – The quality of the depth data has yet to be assessed.		

The full version of this table, including the explanatory notes relating to each category, can be found in Annex A.

The position accuracy is the cumulative error and includes in general survey; geodetic transformation; and digitizing and compilation errors. The higher CATZOC categories, A1 and A2, are categorized by full seafloor search or sweep and very high accuracy standards only achievable with technology that has been available since about 1980. Therefore many sea lanes which have hitherto been regarded as adequately surveyed may carry a ZOC B classification. Modern surveys of critical areas can be expected to carry ZOC A2 classification whilst ZOC A1 will cover only those areas surveyed under exceptionally stringent conditions.[11]

Figure 4-1 below provides a graphical representation of the impact of the position accuracy and depth accuracy on a charted feature; in the graphic, the actual real-world location of the charted 5 metre obstruction may be anywhere within the cylinder, the volume of which is defined by the assigned CATZOC values as defined in Table 4-1 above.

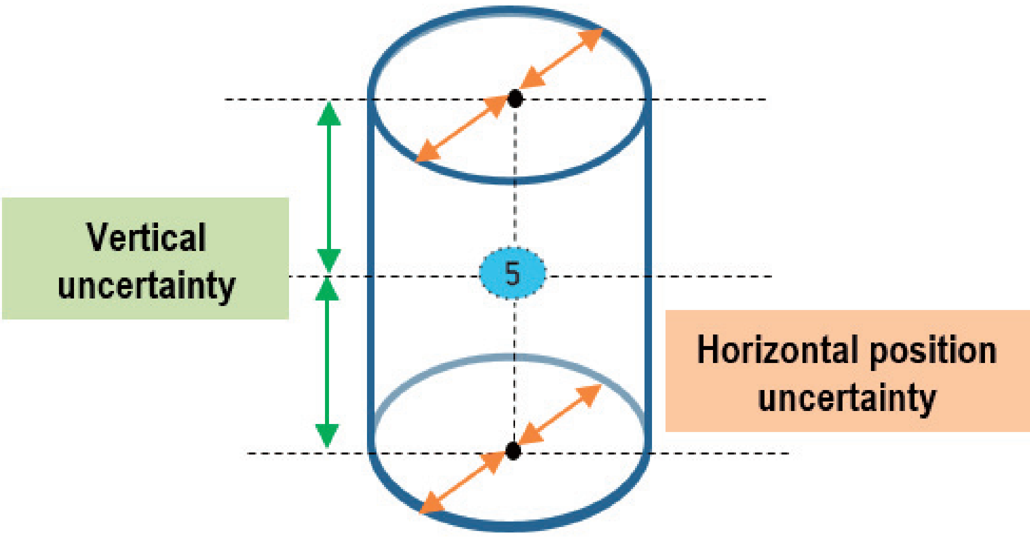


Figure 4-1 – Charted feature depth and position accuracies accounting for ZOCs

[10] Adapted from S-4 clause B-297.4
[11] Adapted from S-4 clause B-297.6

One limitation of the CATZOC system is the lack of information about when a survey was conducted, or whether the seabed is stable. While the date can be provided in an additional data field within an ENC, this is rarely done; and can only be viewed by the mariner using the ECDIS Pick Report function. In areas where the seabed is subject to change, ENC encoding guidance recommends the inclusion of the date of the survey(s) and/or downgrading of the assigned ZOC category, restoring it only once a replacement survey is incorporated in the ENC. However, this isn't always done, so it is wise to note areas of sand-waves; dates within dredged channels; and any other notes advising that channels may have changed or are subject to change.

Figure 4-2 below depicts where a charted shoal may be out of position. The difference between the charted and true position of a shoal may be much greater than the difference between the GNSS measured ship's position and the ship's true position. Mariners are advised to take appropriate caution.

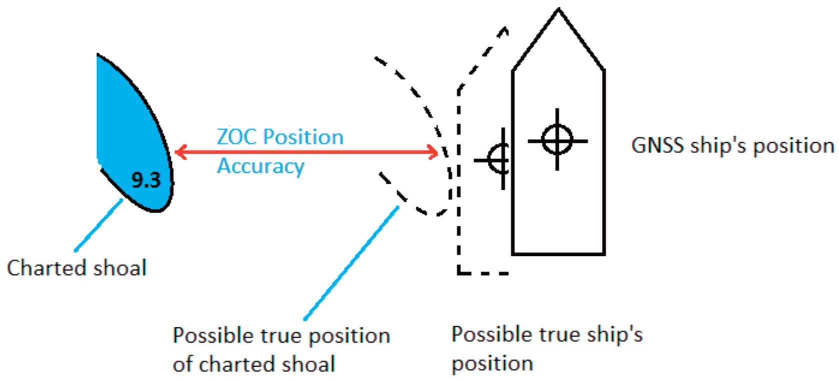


Figure 4-2 – Horizontal position accuracy accounting for ZOCs and ship's GNSS position

- *A planned route should allow for both chart accuracy and ship's positioning accuracy, as well as other factors. The dashed lines indicate the possible worst-case scenario for the mariner.*

For ease of reading, Table 4-1 can be interpreted as follows:

1. High accuracy depth information (ZOC A1 and A2)
2. Medium accuracy depth information (ZOC B)
3. Poor accuracy depth information (ZOC C, D and U).

4.1.1 High accuracy depth information

The depth of this area has been measured by a collection of regular, controlled or systematic hydrographic surveys. Significant seafloor features dangerous to the safety of navigation (rocks, coral reefs, wrecks, submerged obstructions) have been identified, accurately positioned and their least depth value has been accurately determined. Therefore, when route planning in areas with ZOC A1 and A2, the mariner should consider that isolated dangers and shallow soundings could be up to **20 metres** from their charted position; and at least **0.5 to 1 metre** shoaler/deeper than their charted depth (refer to Table 4-4).

4.1.2 Medium accuracy depth information

There is a risk that significant seafloor features dangerous to the safety of navigation (rocks, coral reefs, wrecks, submerged obstructions) have not been identified, and do not appear in the chart. Those features that are present in the chart have a horizontal accuracy of ± 50 metres and a depth accuracy of at least ± 1 metre (refer to Table 4-1). Therefore, when route planning in areas with ZOC B, the mariner should consider that isolated dangers and shallow soundings could be up to **50 metres** from their charted position; and at least **1 metre** shoaler/deeper than their charted depth (refer to Table 4-4).

4.1.3 Poor accuracy depth information

The mariner should take appropriate caution when navigating through this area. Charted depths may in reality be significantly shallower. It is very likely that some significant seafloor features dangerous to the safety of navigation (rocks, coral reefs, wrecks, submerged obstructions) have not been identified, and do not appear in the chart. Those features that are present in the chart have a horizontal accuracy of ± 500 metres and a depth accuracy of at least ± 2 metres (refer to Table 4-1). Therefore, when route planning in areas with ZOC C, D and U, the mariner should consider that isolated dangers and shallow soundings could be up to **500 metres** from their charted position; and at least **2 metres** shoaler/deeper than their charted depth (refer to Table 4-4).

4.2 Quality descriptions of individual objects dangerous to safe navigation

In S-57 – "IHO Transfer Standard for Digital Hydrographic Data", the following (subsurface) items are considered to be hazardous to safe navigation:

- Obstructions
- Rocks and reefs
- Wrecks

The individual encoding of these items, as well as soundings, may contain additional quality information only applicable to the item. The structure of the ENC allows Hydrographic Offices to add this information, however it is not mandatory for them to do so.

Individual obstructions, rocks, reefs, wrecks and soundings may have the following additional quality information:

Table 4-2 – Additional quality information for obstructions, rocks, reefs, wrecks and soundings

Object	Additional information	Options
Obstruction (OBSTRN) Rock (UWTROC) Wreck (WRECKS) Sounding (SOUNDG)	Exposition of sounding (EXPSOU) (Some types of obstructions may have a different least depth to the depth range assigned to the surrounding area, such as a 10 metre wreck lying in a 15 to 20 metre depth area)	1. within the range of depth of surrounding depth area 2. shoaler than the range of depth of surrounding depth area 3. deeper than the range of depth of surrounding depth area
	Quality of sounding (QUASOU) (Values 3, 4, 6, 8, 9 and 11 have essentially the same practical meaning – that the true depth may differ from the charted depth)	4. depth known 5. depth unknown 6. doubtful sounding 7. unreliable sounding 8. no bottom found at value shown 9. least depth unknown 10. least depth unknown, safe clearance at value shown 11. value reported, not surveyed 12. value reported, not confirmed 13. maintained depth 14. not regularly maintained
	Sounding Accuracy (SOUACC) (May be populated only if different from the depth accuracy as indicated by the CATZOC value)	Value in metres
	Technique of sounding measurement (TECSOU) (While some Hydrographic Offices may state the equipment used to determine the position and depth of a feature, mariners should primarily focus on the CATZOC value and other specific quality attributes, rather than the equipment used)	15. found by echosounder 16. found by side-scan sonar 17. found by multi-beam 18. found by diver 19. found by lead-line 20. swept by wire drag 21. found by laser 22. swept by vertical acoustic system 23. found by electromagnetic sensor 24. photogrammetry 25. satellite imagery 26. found by levelling (not applicable) 27. swept by side-scan sonar 28. computer generated

The mariner can execute a "Pick Report" in the ECDIS to show the underlying information of an obstruction, rock, reef, wreck or sounding.

The value of the overlaying CATZOC applies to the horizontal accuracies of individual obstructions, rocks, reefs, wrecks and soundings. However, note that the horizontal position accuracy for individual objects may be encoded using the attributes POSACC and QUAPOS on the associated spatial objects where these individual objects have a different positional accuracy than the overlaying CATZOC indicates.

4.2.1 Obstructions

The following items are considered to be an obstruction[12]:

- Snags
- Stumps
- Wellheads
- Diffusers
- Cribs
- Fish havens
- Foul areas
- Foul ground
- Booms
- Ice booms
- Sites of cleared platforms
- Ground tackle

For obstructions, note the difference between a foul area and a foul ground. A foul area is defined as an area of numerous uncharted dangers to navigation. If the Hydrographic Office creates a foul area in an ENC, it will show in an ECDIS "base display" as an obstruction to navigation, with all associated alarms to indicate that it is unsafe for vessels to enter or transit the area.

Foul ground is defined as an area over which it is safe to navigate but which should be avoided for anchoring, taking the ground or fishing. Foul ground included in an ENC will only show in ECDIS "other display", with no associated alarms or indications. NOTE: Booms, ice booms and ground tackle included in ENC as point objects perform the same in ECDIS as foul ground.

4.3 Survey reliability

The Hydrographic Office may provide additional quality information on individual surveys used in compiling the ENC, using the M_SREL (Survey Reliability) object class. The information, when included in the ENC, can be viewed by executing a pick report on the area. The components of the information are[13]:

[12] S-57 Appendix B.1, Annex A – Use of the Object Catalogue for ENC, clause 6.2.2

Table 4-3 – Components of survey reliability

Attribute	Allowable values	Definitions
Quality of Position (QUAPOS)	1: surveyed	The position(s) was(were) determined by the operation of making measurements for determining the relative position of points on, above or beneath the earth's surface. Survey implies a regular, controlled survey of any date.
	2: unsurveyed	Survey data is does not exist or is very poor.
	3: inadequately surveyed	Position data is of a very poor quality.
	4: approximate	A position that is considered to be within 30.5 metres of its correct geographic location. Also may apply to an object whose position does not remain fixed.
	5: position doubtful	An object whose position has been reported but which is considered to be doubtful.
	6: unreliable	An object's position obtained from questionable or unreliable data.
	7: reported (not surveyed)	An object whose position has been reported and its position confirmed by some means other than a formal survey such as an independent report of the same object.
	8: reported (not confirmed)	An object whose position has been reported and its position has not been confirmed.
	9: estimated	The most probable position of an object determined from incomplete data or data of questionable accuracy.
	10: precisely known	A position that is of a known value, such as the position of an anchor berth or other defined object.
	11: calculated	A position that is computed from data.
Quality of sounding measurement (QUASOU)	1: depth known	The depth from chart datum to the bottom is a known value.
	2: depth unknown	The depth from chart datum to the bottom is unknown.
	3: doubtful sounding	A depth that may be less than indicated.
	4: unreliable sounding	A depth that is considered to be an unreliable value.
	5: no bottom found at value shown	Upon investigation the bottom was not found at this depth.
	6: least depth known	The shoalest depth over a feature is of known value.
	7: least depth unknown, safe clearance at value shown	The least depth over a feature is unknown, but there is considered to be safe clearance at this depth.
	8: value reported (not surveyed)	Depth value obtained from a report, but not fully surveyed.
	9: value reported (not confirmed)	Depth value obtained from a report, which it has not been possible to confirm.
	10: maintained depth	The depth at which a channel is kept by human influence, usually by dredging.
	11: not regularly maintained	Depths may be altered by human influence, but will not be routinely maintained.
Scale value one (SCVAL1)	numerical value (25000 -> scale 1:25 000)	The largest scale for the range of survey scale as used in source diagram information.
Scale value two (SCVAL2)	Numerical value (250000 -> scale 1:250 000)	The smallest scale for the range of survey scale as used in source diagram information.

Attribute	Allowable values	Definitions
Sounding distance – minimum (SDISMN)	numerical value (50 for 50 metres or feet)	The minimum spacing of the principal sounding lines of a survey.
Sounding distance – maximum (SDISMX)	numerical value (150 for 150 metres or feet)	The maximum spacing of the principal sounding lines of a survey.
Survey authority (SURATH)	name of the source survey authority	The authority which was responsible for the survey.
Survey end date (SUREND)	CCYYMMDD CCYYMM CCYY	The ‘survey date, end’ should be encoded using 4 digits for the calendar year (CCYY), 2 digits for the month (MM) (e.g. April = 04) and 2 digits for the day (DD). When no specific month and/or day is required/known, indication of the month and/or the day is omitted. This conforms to ISO 8601: 1988.
Survey start date (SURSTA)	CCYYMMDD CCYYMM CCYY	As for Survey end date above.
Survey type (SURTYP)	1: reconnaissance/sketch survey	A survey made to a lower degree of accuracy and detail than the chosen scale would normally indicate.
	2: controlled survey	A thorough survey usually conducted with reference to guidelines.
	4: examination survey	A survey principally aimed at the investigation of underwater obstructions and dangers.
	5: passage survey	A survey where soundings are acquired by vessels on passage
	6: remotely sensed	A survey where features have been positioned and delimited using remote sensing techniques.
Information (INFORM)	text	Textual information about the object.
Information in national language (NINFOM)	text	Textual information in national language characters.

[13] Adapted from S-57 Appendix A, Chapter 2 – Attributes

It should be noted that, as with CATZOC indication, survey reliability information does not provide any indication regarding the stability of the seabed and the possible difference over time between charted bathymetry and actual depths due to a mobile seabed.

4.4 Depth accuracy in relation to charted depth

CATZOC provides a general impression of the quality of the source data that is used to create depth areas bounded by depth contours. A depth area is an area where the charted depths are bounded by a minimum and (possibly) maximum depth value. A depth contour by default is displayed as a solid line; a boundary between deeper and shallower water. The Hydrographic Office may have provided additional information that the contour line is approximate; it will then be displayed as a dashed line.

Several different depth areas may have the same CATZOC value. On the other hand, more than one CATZOC value may be present within a single depth area

The mariner should take note of the vertical accuracy of the charted depth information (soundings, depth contours, depth areas, dredged areas and underwater hazards) in the areas the vessel is planning to transit and take appropriate caution. Table 4-4 below provides depth accuracy for a range of depths, based on the depth accuracies for the ZOC categories as defined in Table 4-1.

Table 4-4 – Depth accuracy based on CATZOC value

	CATZOC					
depth	**A1**	**A2**	**B**	**C**	**D**	**U**
0	0.5m	1.0m	1.0m	2.0m	>2.0m	unknown
10	0.6m	1.2m	1.2m	2.5m	>2.5m	unknown
20	0.7m	1.4m	1.4m	3.0m	>3.0m	unknown
30	0.8m	1.6m	1.6m	3.5m	>3.5m	unknown
40	0.9m	1.8m	1.8m	4.0m	>4.0m	unknown
50	1.0m	2.0m	2.0m	4.5m	>4.5m	unknown
75	1.3m	2.5m	2.5m	5.8m	>5.8m	unknown
100	1.5m	3.0m	3.0m	7.0m	>7.0m	unknown

However, mariners should note that in ZOC C, D and U, and even possibly ZOC B, undetected (and therefore uncharted) hazards may exist, and these may exceed the depth accuracy of the charted depths.

4.4.1 Safety contour

In an ECDIS the default setting for a safety contour is the 30 metre depth contour. When using the default settings of an ECDIS, depth areas deeper than 30 metres will be presented in white (safe water) and areas shallower than 30 metres will be presented in blue (unsafe water). When a safety contour value is entered into the ECDIS, the system will search for the equal or nearest deeper depth contour (if no contour equal to the value entered are included in the ENC) and assign this as the safety contour to be used. White and blue colours will be adjusted accordingly.

In an ENC, the following standard contour lines are generally available:
0, 2m, 5m, 10m, 20m, 30m, 50m, 100m, 200m, 300m, 400m, 500m, 1000m, 2000m, 3000m, 4000m.

The ENC may also contain additional depth contours, for example:
3m, 8m, 15m, 25m, 40m, 75m, 600m, 700m, 800m, 900m.[14]

In addition to the above contours, some Hydrographic Offices are now producing "High Density (HD) ENCs", which may have a contour interval as small as 0.1 metres covering the depth ranges suitable for the draughts of vessels for which the ENC is intended.

5 Zones of Confidence symbols in ENCs

There are two validations of Zones of Confidence:

- Assessed
- Unassessed

Areas that have been assessed are symbolized by the number of stars. Areas which have not been assessed are symbolized by the letter U.

[14] Adapted from S-4 clause B-411

The number of stars is an indication of the CATZOC value:

6 stars = A1 (in a triangle)

5 stars = A2 (in a triangle)

4 stars = B (in a triangle)

3 stars = C (in a horizontal bar)

2 stars = D (in a horizontal bar)

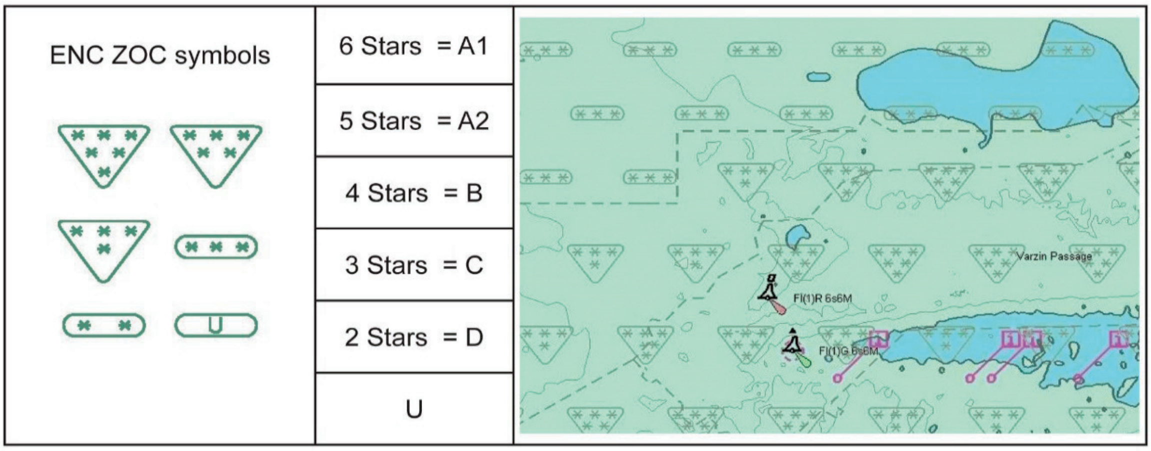


Figure 5-1 – Zones of Confidence symbols, categories and depiction on an ENC

To view the Zones of Confidence symbology, the mariner is required to activate the "information on chart display layer" (or a similar setting, depending on the type of ECDIS used).

The ZOC symbols are placed horizontally across the screen in a regular gridded pattern. The boundary of the CATZOC areas is defined by a dashed line. The ZOC symbol displayed is based on the area defined for each different CATZOC. This means that occasionally only a partial symbol indicating the CATZOC may be depicted, with the symbol being "cut" at the border of adjacent CATZOC areas (thus creating an invalid "composite" symbol, which may be confusing) or at the edge of the ENC cell. This can be seen in Figure 5-1 above, particularly along the boundary separating the ZOC A1 and B areas.

This kind of symbology tends to clutter the screen, therefore during execution of a voyage mariners will most likely de-activate this setting. However, when planning a new route or changing an existing route whilst en-route, mariners are recommended to activate the CATZOC display and use the information provided to support their decision making process before accepting the new route in the ECDIS system.

Quick Reference:

- 5 stars or more = high accuracy depth information area.
- 4 stars = medium accuracy depth information area.
- 3 stars or less = poor accuracy depth information area.
- U = unassessed, take appropriate caution.

5.1 Impact of ZOC categories upon mariners

Put in simple terms, mariners should be able to navigate with confidence in areas with ZOC A1 and A2 classifications. It is possible, but unlikely, that an uncharted danger affecting surface navigation exists in ZOC B areas. In ZOC C areas mariners should exercise caution since hazardous uncharted features may be expected, particularly in or near reef and rocky areas. A very high degree of caution is required for areas assessed as ZOC D, as these contain either very sparse data or may not have been surveyed at all. Finally, it is good practice to treat ZOC U areas with the same degree of caution as ZOC D areas.

To put this in perspective, Table 5-1 below is an overall analysis of over 14 million square kilometres of coastal ENC[15] from 32 nations:

Table 5-1 – Coverage by ZOC category - analysis

ZOC category	% area of English Channel	% area of Singapore & Malacca Straits	% area of world's coastal ENC (32 nations)	Confidence
A1 (6 stars)	12.4%	1.4%	2.5%	Good
A2 (5 stars)	7.1%	0.2%	3.0%	Good
B (4 stars)	43.5%	2.5%	38.5%	Medium
C (3 stars)	21.6%	76.2%	27.8%	Poor
D (2 stars)	12.4%	1.1%	12.5%	Poor
Unassessed (U)	3.0%	18.5%	15.7%	Poor

5.1.1 Effect of over-scaling

The display scales available to mariners in an ECDIS are not standardized and they vary between different ECDIS. Hydrographic Offices on the other hand are recommended by the IHO to compile their ENCs using one of the predefined scale values shown in Table 5-2 below. These scale values, although developed to align as close as possible with standard radar ranges, do not always match the display scale step values available to mariners in ECDIS. Consequently, mariners are strongly recommended, especially during route monitoring, to use the 1:1 ECDIS display setting where available. This setting will display the ENC at the intended viewing scale for the position of the vessel. Mariners will then benefit from the maximum level of detail available in the ENC without the risk of over-scaling.

Table 5-2 – Recommended standard ENC compilation scales

Selectable range	Standard scale (rounded)
200 NM	1:3.000.000
96 NM	1:1.500.000
48 NM	1:700.000
24 NM	1:350.000
12 NM	1:180.000
6 NM	1:90.000
3 NM	1:45000
1.5 NM	1:22.000
0.75 NM	1:12.000
0.5 NM	1:8000
0.25 NM	1:4000

[15] From Navigation Purpose 3 and 4 ENC, covering 14,218,244 SQ KM. World and English Channel figures are from 2020; Singapore and Malacca Straits figures are from 2015. The analysis did not include ports.

There is also a general relationship between the scale of an ENC and its intended purpose. ENCs intended for coastal navigation or approaching a port will generally be compiled at a smaller scale than ENCs intended for more precise navigation and manoeuvring within a port. For instance, on a coastal navigation ENC there is generally no intention by the Hydrographic Office to present the charted information such that mariners can navigate within close proximity of isolated dangers (for example hazards covering an area may be depicted as point features); if this was the intent the ENC would be compiled at a much larger scale. Over-scaling an ENC effectively breaks this relationship between the scale at which the charted information is being displayed and the intended usage of this information.

A large scale chart covers a small area with high level of details. The associated Zones of Confidence therefore also are provided to a high level of detail. When transitioning to a smaller scale chart, at some point two adjacent CATZOC areas will merge into one. At that point only the lesser value of the two CATZOCs will be available for safety reasons. Shipping accidents have occurred when mariners did not have the largest scale chart in their ECDIS available; they over-scaled using a medium scale chart, and ran aground by passing too close to isolated underwater dangers.

Accidents have also occurred due to over-scaling in areas where area obstructions have been generalized to point features due to the scale at which the data has been compiled. Further details and examples are provided in Annex B.

6 Assessment of the quality of a survey into a Zone of Confidence by the Hydrographic Office

ENCs contain different kinds of data collected with different technologies. Some data may be more than 50 years old whereas other data is collected with the latest technology. Some data may be collected using a leadline from a ship, other data may be measured by satellite from space. All this data is compiled to provide an image of the seabed and objects above the seabed. Some data is collected by the Hydrographic Office; other data may come from port authorities, scientific research institutes and through private ship-owners. The Hydrographic Office has the task to evaluate the quality of the data received and decide if and how this data should be made available to update the ENC. This is generally achieved in accordance with the criteria described in Annex A.

As a general guideline, the following choices are made by the Hydrographic Office:

- Data from ports are generally assigned ZOC A1, A2 or B.
- Satellite data are assigned ZOC C.
- Laser data by plane are assigned ZOC B, sometimes A2.
- Private ship-owner data are assigned ZOC D.
- Data before 1980 are assigned ZOC B, C or D. In general, the older the data, the lower the value.

On a case-by-case basis, the Hydrographic Office may deviate from these general guidelines as they see fit, taking into account local knowledge of the area, intended shipping routes etc.

6.1 Assessment examples

Typical survey characteristics are the first considerations when making an assessment of seafloor coverage, depth accuracy and position accuracy. Next, the systematic/non-systematic nature of the survey; does the survey comprise planned survey lines on a known geodetic datum that can be accurately transformed to WGS 84? How accurate are the transformation parameters when converting an old survey (before 1980) to the WGS84 datum used in the ENC? The Hydrographic Office will generally take this into consideration and downgrade the CATZOC areas appropriately.

In this example, a single beam survey conducted in 1963 is very complete. Developments (more survey lines) were made around the shoal areas and crosslines were conducted to see if any shoals existed between survey lines. Due to the completeness of this survey no uncharted features hazardous to surface navigation are expected. The resulting charted depth data would be given CATZOC of B. The area could not be given a CATZOC of A1 or A2 because full seafloor coverage was not achieved. The dynamics of the area could also influence the quality of the data.

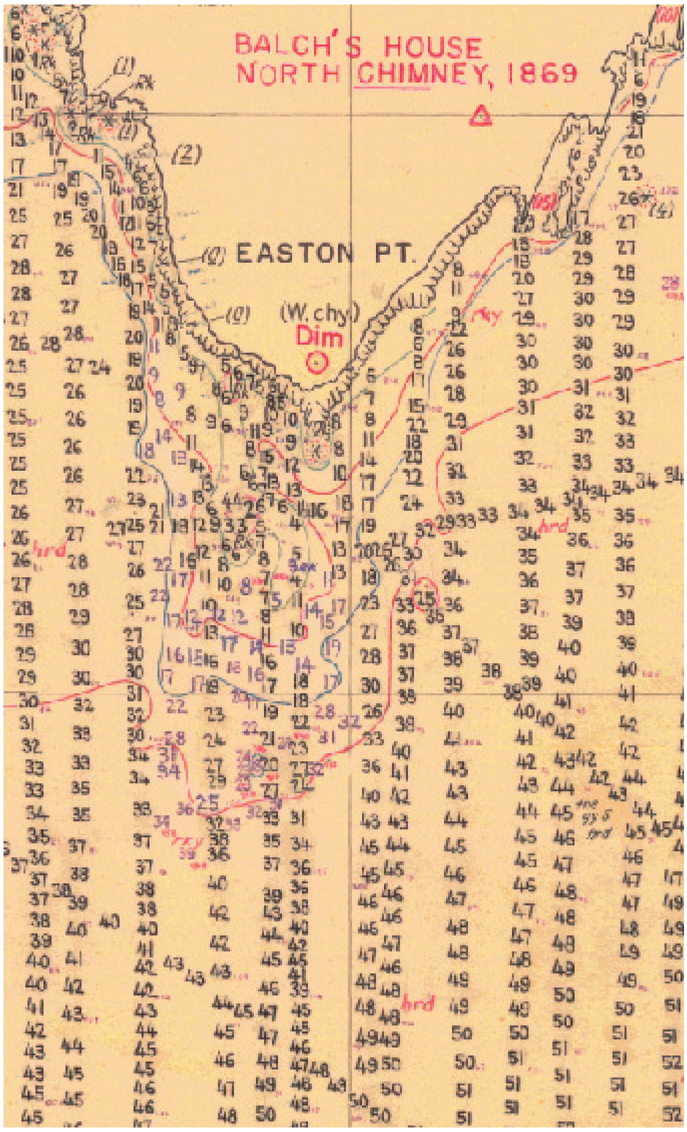


Figure 6-1 – Example: Systematic single beam survey from 1963

In this example, the older hand-drawn survey was completed in 1899. It was done by leadline measurements (recorded in fathoms). These measurements are actually quite accurate. However, they are only isolated measurements, with no guarantee of finding any hazard between one leadline depth and the next. This old survey only includes hazards seen by the surveyors at or above the sea surface. It was assessed as ZOC C – depth anomalies may be expected.*

In contrast, depths taken from the modern metric survey shows a significant 2.1 metre shoal not found during the original survey. It proves that the 1899 survey, if it was the only survey in this area, could not be trusted; and that precautions should be taken.

NOTE: The CATZOC value shown on the ENC would be based on the value assigned to the modern metric survey, however soundings from both surveys may be used.

(1 fathom equals 1.8 metres.)*

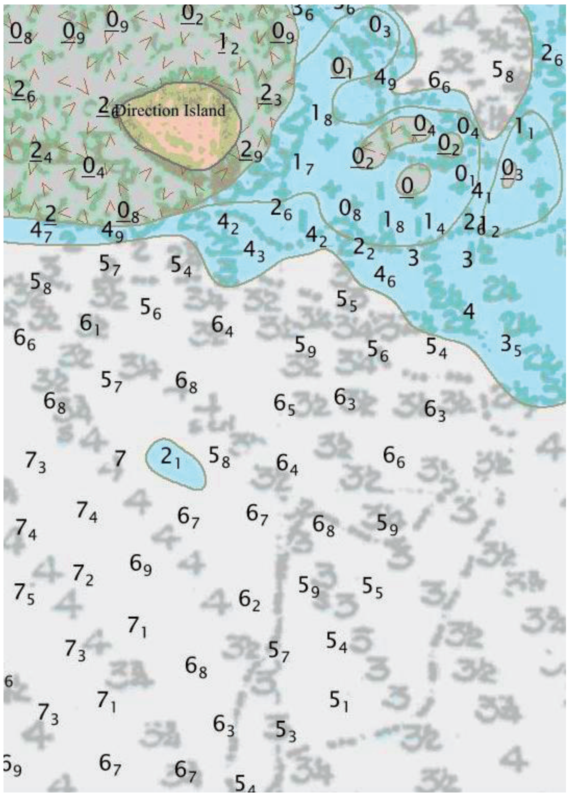


Figure 6-2 – Example: Leadline survey from 1899

6.2 Position accuracy of a survey

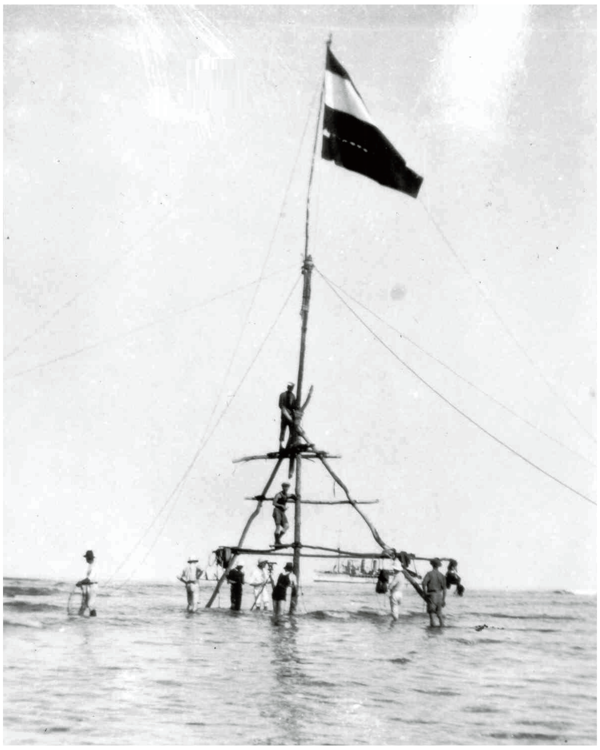
Position accuracy of a survey is typically determined by the positioning systems used during the hydrographic survey. The ability to accurately position a ship anywhere on the globe has significantly improved over the last 100 years.

Since 1978 the US government has provided a space-based radio navigation system, operated by US Air Force. This service, the Global Positioning System (GPS), is available to an unlimited number of users with a GPS receiver. The user can determine accurate time and location, in any weather, day or night, anywhere around the globe. Other countries have provided a similar service, GLONASS (Russian); Beidou (Chinese); and Galileo (EU). A user with a Global Navigation Satellite System (GNSS) receiver can now use all these services at the same time, thus improving the horizontal and vertical accuracy of their position.

The accuracy of a GPS receiver in the 1980s was approximately 30 metres. For hydrographic surveys, a land-based correction signal was supplied to correct for errors introduced by the US Air Force for military purposes; and for signal loss between satellites and receiver. The initial accuracy of 30 metres was initially brought down to 2 metres and eventually to 0.10 metres. The accuracy for a standard GNSS receiver is nowadays in the range of 5 metres, however accuracy of positions in the Arctic can be less due to the fact that the satellites do not pass directly overhead. With the full service of Galileo, the accuracy of a standalone GNSS receiver will become 0.20 metres. This means that the position of the ship will become (far) more accurate than the surveys previously collected and charted.

From the late 1940s to the 1990s survey ships depended upon shore-based electronic positioning systems transmitting their signal over short or medium ranges, giving accuracy of around 20 to 100 metres. In coastal areas, this means that true position of an object could be up to 100 metres from where it was thought to be. Much of this depended upon how accurately the transmitter ashore was positioned, as well as the accuracy of the transmitted ranges to generate the ‘fix’.

Prior to this, survey ships used sextants to measure angles between a system of prominent marks, or flag poles built on towers established ashore, with surveyors 'angling' for hours at a time. A second row of towers could be built in shallow water or on reefs to extend the network further offshore, but with a further reduction in accuracy. Depending upon how accurately the towers were placed, accuracy of 50 to 500 metres was possible for the survey ship. So again, particularly offshore, the true position of an object could quite easily be up to 500 metres from where it was thought to be.



Up to early 1940s: Survey flag on an offshore reef to extend horizontal sextant control further offshore could achieve accuracy typically between 50 – 500 metres of actual position.

Late 1940s to mid-1990s: Shore based electronic position fixing systems could achieve accuracy typically between 20 – 100 metres of actual position.

Figure 6-3 – Position fixing – pre-1940s; late 1940s to 1990s

Further offshore, where information was collected by ships relying entirely upon celestial navigation, positions could be considerably less accurate, typically no better than 1 to 2NM, and frequently worse.

While modern satellite imagery can be used to correct the position of many isolated visible offshore features, such as islands, reefs or perhaps shoals breaking in rough weather, anything more than a few metres below the surface is likely to remain unseen, and therefore possibly charted well out of its true position.

ANNEX A
ZONES OF CONFIDENCE CATEGORIES

Table A-1 – Zones of Confidence categories

ZOC Category (note 1)	Position Accuracy (note 2)	Depth Accuracy (note 3)		Seafloor Coverage	Typical Survey Characteristics (note 5)
A1	± 5 m + 5% depth	=0.50 + 1%d		Full area search undertaken. Significant seafloor features detected (note 4) and depths measured.	Controlled, systematic survey (note 6) high position and depth accuracy achieved using DGPS and a multi-beam, channel or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 0.6		
		30	± 0.8		
		100	± 1.5		
		1000	± 10.5		
A2	± 20 m	= 1.00 + 2%d		Full area search undertaken. Significant seafloor features detected (note 4) and depths measured.	Controlled, systematic survey (note 6) achieving position and depth accuracy less than ZOC A1 and using a modern survey echo-sounder (note 7) and a sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
B	± 50 m	= 1.00 + 2%d		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey (note 6) achieving similar depth but lesser position accuracies than ZOC A2, using a modern survey echo-sounder (note 7), but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
C	± 500 m	= 2.00 + 5%d		Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
		Depth (m)	Accuracy (m)		
		10	± 2.5		
		30	± 3.5		
		100	± 7.0		
		1000	± 52.0		
D	Worse than ZOC C	Worse than ZOC C		Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	Unassessed - The quality of the bathymetric data has yet to be assessed				
Column: 1	2	3		4	5

Source: IHO S-57 Ed3.1 Supp 3 (Jun 2014), pp 13-14

Remarks:

To decide on a ZOC Category, all conditions outlined in columns 2 to 4 of the table must be met.

Explanatory notes quoted in the table:

Note 1. The allocation of a ZOC indicates that particular data meets minimum criteria for position and depth accuracy and seafloor coverage defined in this Table. ZOC categories reflect a charting standard and not just a hydrographic survey standard. Depth and position accuracies specified for each ZOC category refer to the errors of the final depicted soundings and include not only survey errors but also other errors introduced in the chart production process.

Note 2. Position accuracy of depicted soundings at 95% CI (2.45 sigma) with respect to the given datum. It is the cumulative error and includes survey, transformation and digitizing errors etc. Position accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

*Note 3. Depth accuracy of depicted soundings = a + (b*d)/100 at 95% CI (2.00 sigma), where d = depth in metres at the critical depth. Depth accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.*

Note 4. Significant seafloor features are defined as those rising above depicted depths by more than:

Depth Significant Feature
a. <40m: 2 m
b. >40m: 10% depth

A full seafloor search indicates that a systematic survey was conducted using detection systems, depth measurement systems, procedures, and trained personnel designed to detect and measure depths on significant seafloor features. Significant features are included on the chart as scale allows. It is impossible to guarantee that no significant feature could remain undetected, and significant features may have become present in the area since the time of the survey.

Note 5. Typical Survey Characteristics - These descriptions should be seen as indicative examples only.

Note 6. Controlled, systematic surveys (ZOC A1, A2 and B) - surveys comprising planned survey lines, on a geodetic datum that can be transformed to WGS 84.

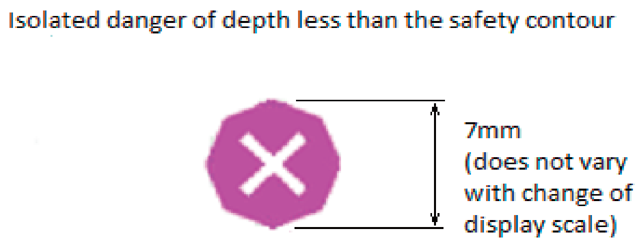
Note 7. Modern survey echo-sounder - a high precision single beam depth measuring equipment, generally including all survey echo-sounders designed post 1970.

DANGEROUS EFFECTS OF OVER-SCALE ECDIS DISPLAY NEAR 'ISOLATED DANGERS'

Use of over-scale display of an ENC may be dangerous in certain circumstances. There is a mistaken belief that zooming in allows for greater accuracy; however, this is not the case. In reality, zooming in beyond the compilation scale of the ENC may be misleading and dangerous, particularly for *'Isolated dangers of depth less than the safety depth'*; as any positional errors included in the data are magnified. The over-scale indicator in the ECDIS should therefore be heeded as a measure to prevent over-scaling the chart.

Every ENC is compiled at an intended maximum viewing scale, known as the compilation scale. At this scale the maximum level of detail is revealed, while zooming out will progressively reduce the level of detail. None of this affects the accuracy of the chart. Zooming in may reveal a new, larger scale ENC, but this too has limits, and a point will be reached where there is no point zooming in further.

At the ENC compilation scale, area details which are too small to chart, but which still present a hazard to navigation, are typically replaced by a point symbol larger than the charted size of the feature (such as a very small reef). Zooming in to over-scale negatively impacts the relationship between the scaled size of the (now larger) real-world area hazard and the size of the symbol.



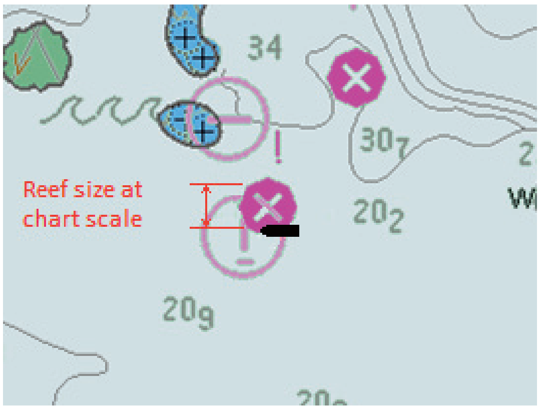
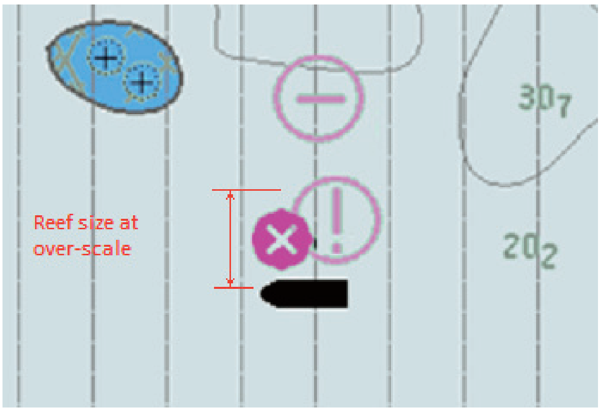
	
When the ENC is displayed correctly (that is, at compilation scale), the danger to a ship close to an isolated danger is clear.	*However, when displayed at over-scale, a ship positioned the same unsafe distance from the isolated danger incorrectly appears to be safe, because the isolated danger symbol is still the same size on the screen.* *This is <u>not</u> more accurate, and is definitely <u>not safe.</u>*

Figure B-1 – Effect of over-scaling on relationship between point symbol and real-world feature

Remember, the positioning accuracy of the isolated danger may be worse than 500 metres. Routes should be planned to clear these dangers by at least as far as the ZOC category immediately around the danger dictates.

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