TABLE OF CONTENTS

PAGE

LESSON 4: ECDIS TARGETS, CHARTS, AND SYSTEM

THE OPERATIONAL USE OF ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEMS (ECDIS)

LESSON 1: ELEMENTS OF ECDIS

CH.1: INTRODUCTION AND FAMILIARIZATION

1.1: General Introduction

In January 1999, the IMO Committee on Standards for Training, Certification and Watch-keeping (STCW) approved a standardized IMO Model Training Course on the Operational Use of ECDIS (IMO Model Course 1.27).

Initially developed by the Institute of Ship Operation, Sea Transport and Simulation (ISSUS) in Hamburg, Germany, the primary objective of the Model Course was to ensure the proper use and operation of ECDIS in terms of a thorough understanding and appreciation of its capabilities and limitations.

The one-week course (40 hours of instruction) model syllabus includes classroom lectures, hands-on training, and exercise scenarios. In addition to providing detailed guidance on a range of subject areas, the Model Course also contains recommendations for facility and staffing requirements, lesson plans, teaching aids, and examples of ship-simulator training exercises.

1.2: Administration

When these standards are fulfilled and the system has been type approved by an authorized body, such as **NK or DNV**, it can be designated an ECDIS. Users should ensure that they have an ECDIS type approval certificate on the vessel in case port state control inspectors want to check whether electronic charts are being used for navigation.

The specifications for ECDIS consist of a set of interrelated standards form these organizations, the ***International Maritime Organization*** (IMO), the ***International Hydrographic Organization*** (IHO), and the ***International Electrotechnical Commission*** (IEC).

Figure 1: ECDIS Display with Pedestal

On its 86th session from May 26 to June 5, 2009, the IMO's Maritime Safety Committee approved new regulations for the mandatory carriage requirement of ECDIS. The amendment to SOLAS Chapter V regulation 19.2 will require ships engaged on international voyages to be fitted with ECDIS according to the following timetable:

TIMETABLE FOR ECDIS CARRIAGE REQUIREMENTS			
Ship Type	Size	New Ship	Existing Ship
Passenger Ships	≥500 gross tons	1 July 2012	No later than 1st survey after 1 July 2014
Tankers	≥3,000 gross tons	1 July 2012	No later than 1st survey after 1 July 2015
Dry Cargo Ships	≥50,000 gross tons	1 July 2013	No later than 1st survey after 1 July 2016
	≥20,000 gross tons (new ships) 20,000-50,000 gross tons (existing ships)	1 July 2013	No later than 1st survey after 1 July 2017
	≥10,000 gross tons (new ships) 10,000-20,000 (existing ships)	1 July 2013	No later than 1st survey after 1 July 2018
	3-10000 gross tons	1 July 2014	No retrofit requirements to existing ships <10,000 gross tons

NOTE: Ships may be exempt from the requirements if they will be taken permanently out of service within two years after the implementation date specified.

IMO

The IMO amendments to the international convention for SOLAS (Safety of Life at Sea) make it compulsory to fit an ECDIS.
The legislation will be phased by vessel type and size and will eventually apply to almost all large merchant and passenger ships. Use below timetable to determine which of your vessel(s) will be affected and when:

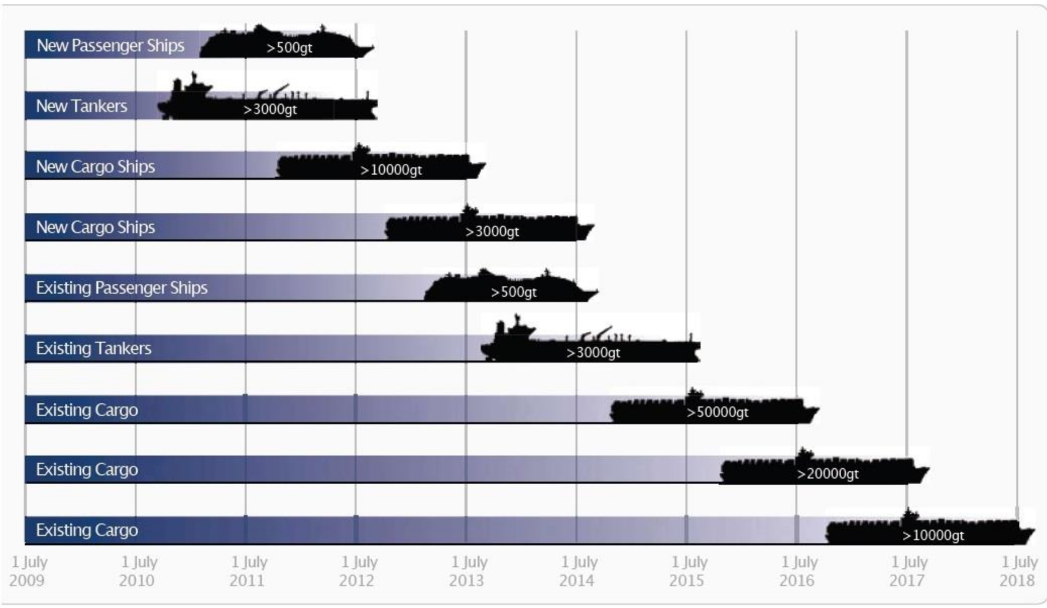


Figure 1.2: Carriage Requirements

An amendment to the existing Chapter V regulation 19.2.1.4 was also made to reflect that ECDIS is an acceptable alternative to nautical charts and nautical publications. However, it stipulates that it is appropriate to use only nautical charts and publications in a number of cases – for example ships not on international voyages, ships exempt from the carriage requirements because they were to be permanently taken out of service and cargo ships on international voyages but below the agreed tonnage limit.

Port State Control and Flag State Requirements

Though the IMO crafted the resolution that will make ECDIS mandatory on steadily more commercial ships over the next few years, the IMO has no power to enforce compliance to it. The role of enforcement falls upon the national governments and/or international or regional governing bodies. Once a government has become a signatory to an IMO convention, the rules in that convention are adopted as national laws and regulations, which impact any ship carrying that nation's flag or any ship visiting that government's ports. These are then enforced during flag state and port state inspections, usually carried out under the auspices of a national maritime administration (such as the United States Coast Guard).

The requirements to ships flying a nation's flag (flag state requirements) and the requirements to ships visiting that same nation's ports (port state control requirements) are usually the same; the requirements from nation to nation, or government to government, however, often differ, even if they are derived from the very same IMO Convention.

Shipowners will of course be familiar with the rules and regulations of their ships' flag state authorities. Regional affiliations of port state authorities (such as the Paris Memorandum of Understanding, a coalition of 27 European and North Atlantic maritime administrations) provide guidelines to owners of ships that will call at ports in their region.

Port state control inspections will seek to ascertain whether any and every commercial vessel visiting a country's ports is being operated in accordance with national laws and international regulations. In the instance of mandatory ECDIS, the relevant international regulation is IMO's SOLAS Convention.

The Tokyo MoU (Memorandum of Understanding) region, which aligns the port state control functions in Far East Asia, carried out in late 2008 a concentrated inspection campaign on safety of navigation. The most notable deficiency found during this campaign was related to lack of adequate charts and publications (57.39 per cent). Despite the fact that these inspections all follow the requirements laid out in the IMO's SOLAS Convention, different interpretations of this convention has resulted in different guidelines from country to country, and regime to regime. A port state control officer will refer to the statement from the flag state authority, which is onboard every vessel, and will control the ship according to these requirements. Port state control officers differ in their expertise, but many have a background from navigation and steadily more will have experience with ECDIS systems. As a result, one should expect the proficiency and rigor of these systems' control to increase over time.

A list of items subject to inspection by the Paris MoU (the European region) is indicative of what port state control authorities will check. These include:

1) Documentation indicating that the ship's navigation system complies with IMO Performance Standards for ECDIS Port state will either ask for written documentation that attests to the ECDIS system's compliance, or look on the ECDIS system itself for markings that attest to the same. It is the flag state's responsibility to ensure that the ship possesses this documentation.

2) Written procedures onboard the vessel for using the ECDIS system Port state considers the ECDIS system as critical bridge equipment, and will thus seek readily available instructions for bridge personnel. These procedures should cover incidents such as equipment failure or power failure, and give watchkeepers a quick and clear reference.

3) The master and watch-keeping officers are able to produce appropriate documentation that generic and type-specific ECDIS familiarisation has been undertaken Port state will seek certification that the bridge team has been trained in its use. <u>This training should generally include a general course including the IMO model course syllabus (a five-day programme), and a course specific to the ECDIS make – a "buttons and knobs" familiarisation course.</u> Port state may also request watch-keepers to demonstrate proficiency (find an ENC, enter a position, enter a bearing line, etc.

4) The ship is equipped with the latest updates and new editions of ENCs. The port state control officer may investigate the data presented on the ECDIS screen to determine if it is an official ENC, if it is updated recently and if it includes the most recent Notices to Mariners.

5) The ship is equipped with correct usage bands for the entire upcoming voyage. The port state control officer may check the voyage planning by seeing if the whole route is available, at the appropriate scales.

6) The ship is equipped with additional nautical publications, as defined by the national carriage requirements. This requirement is one that is familiar to all navigators, with or without ECDIS, and is determined by flag state requirements.

7) There is agreement between sensor data and its presentation on the ECDIS system Port state will look at the representation on the ECDIS to make sure that the ship appears where it should, that it is pointed in the right direction, that the ship is in the correct position on the ECDIS and that the ship’s vector is aligned.

8) The ship is equipped with an approved back-up arrangements to ensure safe navigation of the entire voyage, in the event of an ECDIS failure Port state will investigate whether the ship’s back-up navigation arrangements are in accordance with flag state requirements, and whether these arrangements are up to specification and ready to use. If a ship is using dual ECDIS, it does not need two separate power sources, but the port state control officer may examine how the sensors are divided, to ensure the back-up ECDIS is a valid back-up.

9) The ship is equipped with an updated collection of paper charts, if the ECDIS system is being used in RCDS mode (Raster Chart Display System) Port state will determine whether the appropriate paper charts are onboard, whether they are marked with a course line and whether positions have been noted at regular intervals.

1.3: Familiarization with ECDIS

Historical Background

(a) The concept of electronic charts goes back nearly 60 years, to at least 1952, when an article in the Journal of Navigation suggested combining radar imagery with digitized chart data. At the time, however, the technology to handle the data was a serious limiting factor resulting in not much more than speculation.

(b) In 1986 the North Sea Hydrographic Commission completed a study on the consequences of the development of Electronic Chart Display and Information Systems (ECDIS) for Hydrographic Offices.
Its conclusions were, amongst others:
   (1) Specifications for standardized data content, format and updating procedures should be arrived at by a new IHO ECDIS Working Group as a matter of high priority.
   (2) To assure the integrity of Electronic Navigational Charts (ENC's), their production should be the responsibility of the Hydrographic Offices; the ENC's

will be made available in a standard format and all equipment should be designed to accept it.

(3) When official ENC's are available, ECDIS users should be required to carry them in full, and ECDIS manufacturers or other intermediaries should not make preliminary selections of data before supplying them to the mariners.

(c) It was then decided to establish an International Hydrographic Organization (IHO) Committee on ECDIS (COE). (*COE now redefined as "CHRIS", Committee on Hydrographic Requirements for Information Systems*)

(d) As several manufacturers were now developing these systems, it was of immediate importance to all concerned (Hydrographic Offices, mariners, national shipping authorities, manufacturers) to have at least a first draft of the IHO and International Maritime Organization (IMO) guidance for both the Electronic Navigation Chart (ENC) and its display systems.

(e) For that reason the COE-chairman asked the Netherlands Hydrographer to prepare a working paper on ECDIS specifications, to be further discussed in the COE*.

(f) The aim of this working paper was to evolve and recommend:

(1) Minimum and supplementary data content of the ENC and required characteristics of that data base such as the cataloguing of sea areas, density of digitization of chart data and reliability and worldwide compatibility of chart data and other nautical information produced.

(2) Minimum and supplementary content of the ENC Display, standards of symbols, colours and their standardized assignment to features, scale limitations of data presentation, and appropriate compatibility with paper chart symbols as standardized in the Chart Specifications of the IHO.

(3) Methods for the timely updating of the ENC, and means to ensure worldwide compatibility of the correction system data.

(4) Criteria for a standard format for exchange of digital data for the ECDIS between Hydrographic Offices and for supply to the data user, and procedures and financial aspects of such an exchange and supply.

(g) A first draft of the specifications was presented to IHO Member State Hydrographers in May 1987 at the 13th International Hydrographic Conference in Monaco. This draft was also widely distributed to National Shipping Authorities, mariner associations and manufacturers, for comment. Since then, S-52 and its relevant appendices have been updated several times and this is the 65th edition of S-52. The 5th edition was necessary to reflect changes in related standards.

(h) In parallel with the development of the IHO Specifications, the IMO/IHO Harmonizing Group on ECDIS developed Provisional Performance Standards for ECDIS which were first published in May 1989 by the IMO.

An amended version of the Provisional Performance Standards was prepared in the light of experience and was presented in September 1993 to the IMO Sub-Committee on the Safety of Navigation, which endorsed it and submitted the Performance Standards for ECDIS to the IMO Maritime Safety Committee, for approval and submission to the 1995 IMO Assembly for adoption. The current version of the Performance Standards has been promulgated as MSC Circular 637, dated 27 May 1994. The Performance Standard was adopted by IMO resolution A.817 (19) dated 23 November 1995. The Performance Standards have incorporated many of the elements of the original IHO Specification. For that reason, S-52 now only provides the details of the hydrographic requirements for ECDIS.

(i) While many of the general elements of S-52 were being incorporated in the IMO Performance Standards, the specifics were being expanded in S-52 Appendix 2 "Colour & Symbol Specifications" into a model for presenting all chart and navigational objects on the ECDIS display, according to the developing IMO requirements. IHO published a provisional edition of S-52 App.2 in 1991 and the first operational edition, complete with Annex A "Presentation Library", was issued in 1994.

(j) The IHO Committee on Hydrographic Requirements for Information Systems (CHRIS) developed S-57, “IHO Transfer Standard for Digital Hydrographic Data“. S-57 describes the standard to be used for the exchange of ENC data. S-57 was adopted as the official IHO standard by the 14th International Hydrographic Conference, Monaco, 4-15 May 1992.

(k) An important milestone in the development of ECDIS specifications was the introduction of the “ENC Product Specification“. The “ENC Product Specification“ is included in S-57 as Appendix B1 and gives detailed specifications for the ENC structure and content.

(l) In 1997 the IMO Sub-Committee on the Safety of Navigation adopted the so called „dual fuel” Raster Chart Display System (RCDS) ECDIS mode, accepting official raster data (Raster Navigational Chart or RNC) together with an appropriate folio of paper charts as meeting a vessel’s chart carriage requirements in the absence of S-57 vector chart data coverage for the operating area. The Performance Standards were amended appropriately and the IHO published S-61 containing the RNC product specification.

(m) The revision of the 1974 SOLAS Convention in December 2000 accepts ECDIS as legal equipment to fulfill the carriage requirement for nautical publications on board of vessels subject to the SOLAS regulations.

(n) The CHRIS Committee decided on its 15th. Session in May 2003 to remove all operational requirements for ECDIS from this Specification (S-52) as well as the detailed description of “Navigational Symbols” from Appendix 2 of this Specification in order to hand these over to the sole responsibility of IEC TC80. IEC TC80 will incorporate the operational requirements in the upcoming new edition 3 of IEC 61174 “ECDIS Performance Standards, methods of testing and required test results” and the navigational symbols in the upcoming new standard IEC 60288 “Presentation of navigation related information”.
From now on S-52 and Appendix 2 in particular is focused on the display aspects and the colour and symbol definition of chart information on ECDIS. In order to maintain consistent display procedures for charted and operational information S-52, Appendix 2 will continue the provision of appropriate entries in colour tables, viewing groups, look-up tables and conditional procedures for the presentation of navigational symbols.

(SPECIFICATIONS FOR CHART CONTENT AND DISPLAY ASPECTS OF ECDIS - Draft 6th Edition Special Publication No. 52 published by the International Hydrographic Bureau MONACO)

Additional Significant Events in the Development of ECDIS:

Early 1980s: Rudimentary Electronic Charting Systems (ECS) became available. During the early 1980’s, the member countries of the International Hydrographic Organization (IHO) identified that the emerging computer technology could provide a digital representation of the paper chart on a computer screen, along with real-time positioning and interfaces to radar and other navigation sensors. The IHO formed several working groups to define the standards for data encoding and digital chart presentation. From this early work, the Electronic Chart Display and Information System (ECDIS) evolved.

1983: IMO adopted a Resolution referring to the importance of the provision of accurate and up-to-date hydrographic information

1985: IMO adopted a Resolution urging IMO Member Governments to establish regional hydrographic commissions to support the IHO

1985: The term ECDIS was born through work by the North Sea Hydrographic Commission

1986: The IMO established its IMO/IHO joint Harmonization Group on ECDIS (HGE)

1995: IHO finalized the standard for vector charts (S-57, Ver. 3)

1995: IMO adopts performance standards for ECDIS resolution A.817 (19)

1996: A.817 (19) was amended by resolution MSC.64 (67) to reflect back-up arrangements in case of ECDIS failure

1998: A.817 (19) was amended by resolution MSC.86 (70) to permit operation of ECDIS in RCDS (Raster chart) mode

1998: The 1st International ECDIS Conference was held in Singapore from Oct. 26~28, 1998 with the theme, “ECDIS - An Effective Tool for Safe Navigation”.

1998: The first edition of IEC standards for ECDIS, IEC 61174, was published.

11 June 2001: STCW.7/Circ.10 Interim Guidance on Training and Assessment in the Operational Use of the Electronic Chart Display and Information System (ECDIS) Simulators.

The Maritime Safety Committee, at its seventy-fourth session (30 May to 8 June 2001), approved this interim guidance.

2002: SOLAS V recognizes ECDIS as meeting chart carriage requirements for navigation

1 July 2002. **-** IMO's Maritime Safety Committee (MSC), at its 73rd session from 27 November to 6 December 2000 adopted a revised Chapter V (Safety of Navigation) of SOLAS and entered into force.

2003: The 2nd International ECDIS Conference was held in Singapore from Oct. 07~09, 2003 with the theme, “ECDIS for Coastal and Ocean Navigation”.

2009: The 3rd International ECDIS Conference was held in Singapore from Oct. 19~21, 2009 with the theme, “ECDIS - Beyond Navigation”.

July 2010: All High Speed Craft mandated to be fitted with ECDIS.

2012: STCW makes ECDIS training mandatory if serving on a ship fitted with ECDIS.

July 2012: SOLAS V makes ECDIS a mandatory fit for vessels on an 8 year timetable dependent upon class.

References:
http://ecdis.org/purchasing/about_ecdis/ecdis_timeline/
http://www.iho.int

What is an ECDIS?

An **Electronic Chart Display and Information *System*** *(ECDIS)* is a navigation information system which with adequate back-up arrangements can be accepted as complying with the up-to-date chart required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended, by displaying selected information from a system electronic navigational chart (SENC) and with position information from the Global Positioning System (GPS) and other navigational sensors, such as radar, fathometer and Automatic Identification Systems (AIS), to assist the mariner in route

<u>planning and route monitoring, and if required, display additional navigation-related information.</u>

A **Raster Chart Display System (RCDS)** means a navigation information system displaying RNCs with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and if required, display additional navigation-related information. (Serve as a back-up if an area does not have an ENC)

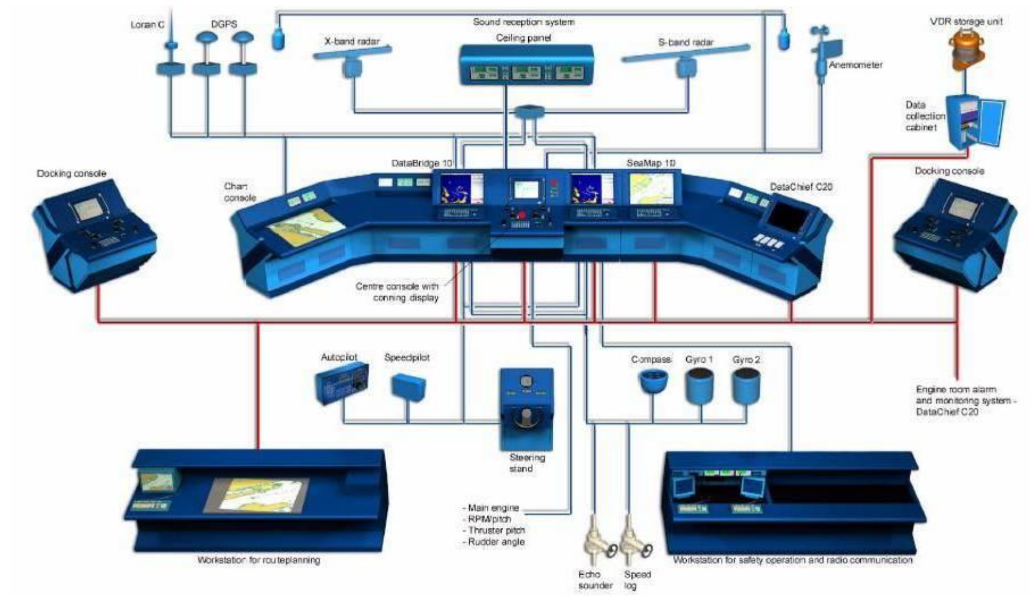


Figure 1.3: ECDIS and other Navigation Equipment Overview

Components of ECS's and ECDIS's

The terms ECS and ECDIS encompasses many possible combinations of equipment and software designed for a variety of navigational purpose. In general, the following components comprise an ECS or ECDIS.

❖ **Computer Processor, Software, and Network:** These subsystems control the processing of information from the vessel's navigation sensors and the flow of information between various system components. Electronic positioning information from GPS or Loran C, contact information from radar, and digital compass data, for example, can be integrated with the electronic chart data.

❖ **Chart Database:** At the heart of any ECS lies a database of digital charts, which may be in either raster or vector format. It is this dataset, or a portion of it, that produces the chart seen on the display screen.

❖ **System Display:** This unit displays the electronic chart and indicates the vessel's position on it, and provides other information such as heading, speed, distance to the next waypoint or destination, soundings, etc. There are two modes of display, **relative** and **true**. In the relative mode the ship remains fixed in the center of the screen and the chart moves past it. This requires a lot of computer power, as all the screen data must be updated and re-drawn at each fix. In true mode, the chart remains fixed and the ship moves according to the availability of data from a heading sensor such as a digital compass.

❖ **User Interface:** This is the user's link to the system. It allows the navigator to change system parameters, enter data, control the display, and operate the various functions of the system. Radar may be integrated with the ECDIS or ECS for navigation or collision avoidance, but is not required by SOLAS regulations.

(Other reference gives 5 components which are: Electronic Chart Data, Computer Processer and related hardware, Electronic Chart Software, Electronic Interconnections, and User Interface. *Ref. ECDIS and Positioning*.

The Main functions of an ECDIS equipment:

- Chart management
- Integrate navigation sensors
- Plan routes on chart display
- Quality checking of routes
- Continuous monitoring of the own ship in relation to the route plan
- Grounding alarm
- Display of ARPA tracks
- Voyage recording and replay
- Integrated weather routing
- Echo sounder monitoring of chart depth information
- Digitizing routes and charts

CH. 2: PURPOSE OF ECDIS

As per the revised IMO Performance Standards for ECDIS (June 2006, Resolution MSC.232 (82)), it states that the primary function of the ECDIS is to contribute to safe navigation. It should be capable of displaying all chart information necessary for safe and efficient navigation originated by, and distributed on the authority of, government authorized hydrographic offices. It should facilitate simple and reliable updating of the electronic navigational chart. It should reduce the navigational workload compared to using the paper chart. It should enable the mariner to execute in a convenient and timely manner all route planning, route monitoring and positioning currently performed on paper charts. And be capable of continuously plotting the ship's position. It should have at least the same reliability and availability of presentation as the paper chart published by government authorized hydrographic offices. And it should provide appropriate alarms or indications with respect to the information displayed or malfunction of the equipment.

2.1: Revised IMO Performance Standards for ECDIS (June2006, Resolution MSC. 232(82))

RESOLUTION MSC. 232(82)
(Adopted on 5 December 2006)
Adoption of the Revised Performance Standards For
Electronic Chart Display and Information Systems (ECDIS)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution A.886(21), by which the Assembly resolved that the function of adopting performance standards and technical specifications, as well as amendments thereto shall be performed by the Maritime Safety Committee and/or the Marine Environment Protection Committee, as appropriate, on behalf of the Organization,

RECALLING ALSO regulations V/19 and V/27 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, which requires all ships to carry adequate and up-to-date charts, sailing directions, lists of lights, notices to mariners, tide tables and all other nautical publications necessary for the intended voyage,

NOTING that the up-to-date charts required by SOLAS regulations V/19 and V/27 can be provided and displayed electronically on board ships by electronic chart display and information systems (ECDIS), and that the other nautical publications required by regulation V/27 may also be so provided and displayed,

RECOGNIZING the need to improve the previously adopted, by resolution A.817(19), as amended, performance standards for ECDIS in order to ensure the operational reliability of such equipment and taking into account the technological progress and experience gained,

HAVING CONSIDERED the recommendation made by the Sub-Committee on Safety of Navigation, at its fifty-second session,

1. ADOPTS the Revised performance standards for electronic chart display and information systems (ECDIS), set out in the Annex to the present resolution;
2. RECOMMENDS Governments ensure that ECDIS equipment:
   (a) if installed on or after 1 January 2009, conform to performance standards not inferior to those specified in the Annex to the present resolution; and

   (b) if installed on or after 1 January 1996 but before 1 January 2009, conform to performance standards not inferior to those specified in the Annex to resolution A.817(19), as amended by resolutions MSC.64(67) and MSC.86(70).

Revised Performance Standards for
Electronic Chart Display and Information Systems (ECDIS)

1. SCOPE OF ECDIS

1.1. The primary function of the ECDIS is to contribute to safe navigation.

1.2. ECDIS with adequate back-up arrangements may be accepted as complying with the up-to-date charts required by regulations V/19 and V/27 of the 1974 SOLAS Convention, as amended.

1.3. ECDIS should be capable of displaying all chart information necessary for safe and efficient navigation originated by, and distributed on the authority of, government authorized hydrographic offices.

1.4. ECDIS should facilitate simple and reliable updating of the electronic navigational chart.

1.5. ECDIS should reduce the navigational workload compared to using the paper chart. It should enable the mariner to execute in a convenient and timely manner all route planning, route monitoring and positioning currently performed on paper charts. It should be capable of continuously plotting the ship's position.

1.6. The ECDIS display may also be used for the display of radar, radar tracked target information, AIS and other appropriate data layers to assist in route monitoring.

1.7. ECDIS should have at least the same reliability and availability of presentation as the paper chart published by government authorized hydrographic offices.

1.8. ECDIS should provide appropriate alarms or indications with respect to the Information displayed or malfunction of the equipment (see appendix 5).

1.9. When the relevant chart information is not available in the appropriate form (see section 4), some ECDIS equipment may operate in the Raster Chart Display System (RCDS) mode as defined in appendix 7. RCDS mode of operation should conform to performance standards not inferior to those set out in appendix 7.

2. Application of these Standards

2.1 These performance standards should apply to all ECDIS equipment carried on all ships, as follows:
- dedicated stand-alone workstation.
- a multifunction workstation as part of an INS.

2.2 These performance standards apply to ECDIS mode of operation, ECDIS in RCDS mode of operation as specified in appendix 7 and ECDIS backup arrangements as specified in appendix 6.

2.3 Requirements for structure and format of the chart data, encryption of chart data as well as the presentation of chart data are within the scope of relevant IHO standards, including those listed in appendix 1.

2.4 In addition to the general requirements set out in resolution A.694 (17)*, the Presentation requirements set out in resolution MSC.191 (79), ECDIS equipment should meet the requirements of these standards and follow the relevant

2.2: Different Display Options

While manufacturers of electronics chart system have designed their own proprietary colors and symbols, the IMO Performance Standard requires that all IMO approved ECDIS follow the International Hydrographic Organization (IHO) Color and Symbol Specifications. These specifications are embodied in the ECDIS Presentation Library. Their development was a joint effort between Canada and Germany during the 1990s. In order for ECDIS to enhance the safety of navigation, every detail of the display should be clearly visible, unambiguous in its meaning, and uncluttered by superfluous information. The unofficial ECS's continue to be free to develop independent of IHO control. In general they seek to emulate the look of the traditional paper chart.

To reduce clutter, the IMO Standard lays down a permanent display base of essentials such as depths, aids to navigation, shoreline, etc., making the remaining information selectable. The navigator may then select only what is essential for the navigational task at hand. A black-background display for night use provides good color contrast without compromising the mariner's night vision. Similarly, a "bright sun" color table is designed to output maximum luminance in order to be daylight visible, and the colors for details such as buoys are made as contrasting as possible.
The display operates by a set of rules, and data is arranged hierarchically, for example, where the lines overlap, the less important line is not drawn.

2.2.1: Electronic Navigational Chart (ENC)

The Electronic Navigational Chart (ENC) is a file containing the official chart data that an ECDIS utilizes. It stores the chart information in the form of geographic objects represented by point, line and area shapes, carrying individual attributes, which make any of these objects unique.

Produced and authorized by national hydrographic authorities such as Hydrographic Offices, ENCs are vector charts that conform to IHO specifications. When used in an ECDIS, the data can be reassembled to display either an entire chart image or a user selected combination of chart data. ENCs are "intelligent" in that systems using them can be programmed to warn of impending danger in relation to charted information and the vessel's position and movement.

ENCs are vector charts compiled from a database of individual geo-referenced objects from Hydrographic Office's archives including existing paper charts. When used in an ECDIS, the ENC content can be displayed as a seamless pattern in user selected scales presenting user selected chart items. The chart image generated from ENCs is not simply a reproduction of the corresponding paper chart. Its differing appearance is intended to increase visibility and situational awareness and to allow overlays to work without adversely affecting safety, as well as to fit the limited size and resolution of computer monitors. The ENC is a data file: special ECDIS operational functions continuously retrieve the ENC content to give warning of impending danger in relation to the vessel's position and its movement.

IMO Definition:
ENC means the database, standardized as to content, structure and format, issued for use with ECDIS on the authority of government-authorized Hydrographic Offices. The ENC contains all the chart information useful for safe navigation, and may contain supplementary information in addition to that contained in the paper, which may be considered necessary for safe navigation.

Official ENCs have the following attributes:
1. ENC content is based on source data or official charts of the responsible Hydrographic Office;
2. ENCs are compiled and coded according to international standards;
3. ENCs are referred to World Geodetic System 1984 Datum (WGS84);
4. ENC content is the responsibility of the issuing Hydrographic Office;
5. ENCs are issued only by the responsible Hydrographic Office; and
6. ENCs are regularly updated with official update information distributed digitally.

S57 Vector Format

ECDIS is compatible with S57 release 3 ENC format charts. From this format, the ECDIS generates the "system ENC", = SENC, which is used for actual operations of the ECDIS.

When you open a chart, it is displayed with the default scale, called the compilation scale. The details for the chart are displayed in the electronic chart area and these can be modified. You can change the chart scale with the ZOOM IN and ZOOM OUT functions, and the scale range is 1:1,000 - 1:50,000,000.

CM-93

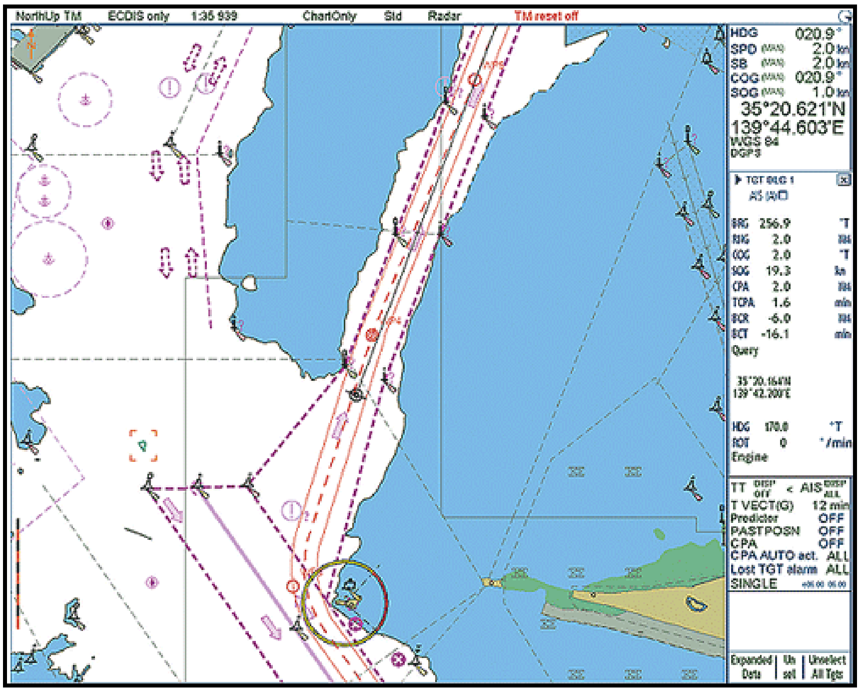
Compatibility with CM-93 format depends on commercial agreements. Some versions of this ECDIS are compatible and others are not. The compatibility is controlled by the security device called a dongle. From CM-93 format the ECDIS generates SENC which is used for actual operations of the ECDIS. The difference between S57ed3 ENC charts and CM-93 charts is that the CM-93 charts are from a private source and they cannot be used as a substitute for paper charts under any condition. To emphasize this point these charts are called "Non-ENC" charts.

System Electronic Navigation Chart (SENC)

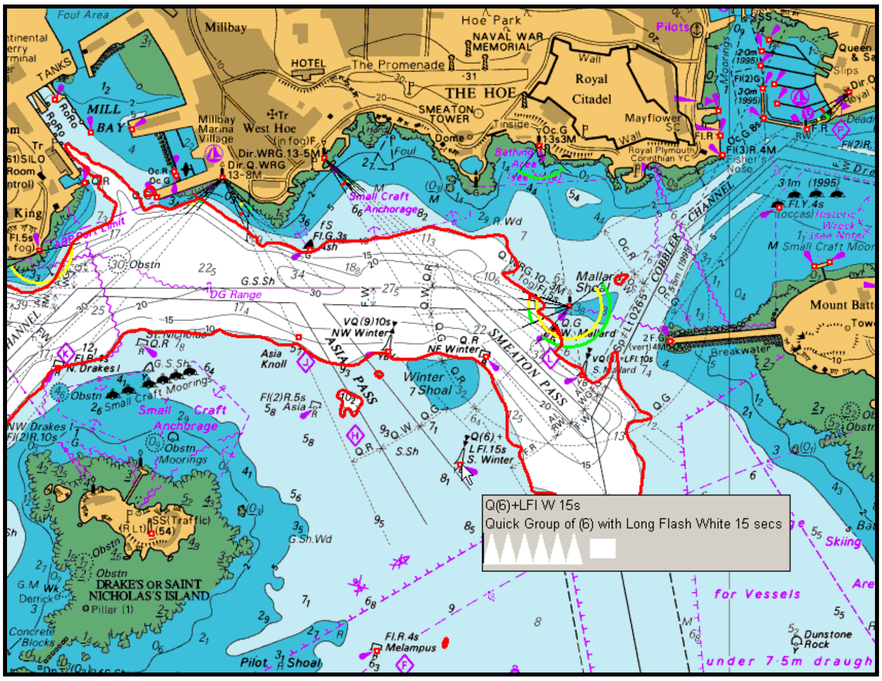
An ECDIS does not process the ENC content directly to the screen. In order to display ENC data quickly enough, ECDIS converts each ENC from S-57 ENC format into an internal format called the System Electronic Navigational Chart (SENC), which is optimized for chart image creation.

However, the SENC format may differ between the ECDIS of different manufacturers. In contrast to the common uniform ENC format, the SENC format is dependent upon the choice of each ECDIS manufacturer. The characteristics of SENC are defined in paragraph 2.3 of the ECDIS Performance Standard. Chart updates, either received electronically or applied manually will be incorporated into the SENC directly.

The IMO definition in the IMO Performance Standards for ECDIS:
The System Electronic Navigational Chart (SENC) means a database resulting from the transformation of the ENC by ECDIS for appropriate use, updates to the ENC by appropriate means and other data added by the Mariner. It is this database that is actually accessed by ECDIS for the display generation and other navigational functions and is the equivalent to an up-to-date paper chart.



Raster Navigational Chart (RNC) means a facsimile of a paper chart originated by, or distributed on the authority of, a government-authorized hydrographic office. RNC is used in these standards to mean either a single chart or a collection of charts.



The IMO definition in the IMO Performance Standards for ECDIS: (Appendix 7 3.3)

System Raster Navigational Chart Database (SRNC) means a database resulting from the transformation of the RNC by the RCDS to include updates to the RNC by appropriate means.

The IHO has released a product specification for raster charts known as S-61 which does not define the detailed structure of RNC data but puts certain minimum requirements on it, particularly concerning what meta-data should be included. Most of the data in raster chart is the actual image of the chart; the *meta-data* is separate from the image but is accessed by the RCDS software running on an ECDIS.

2.2.2: The various information provided by the system is made available to the users through the displays; there are three categories of displays available on the display of an ECDIS:

- **Base Display**

The display base is considered to be minimum information that is allowed to be displayed on the ECDIS. More information may be added but the ECDIS will not permit a user to subtract detail form the display base. In general, it is not sufficient for safe navigation. It consists of:

- Coastline (high water)
- Own ship's safety contour
- Isolated underwater dangers of depths less than the safety contour which lie within the safe waters defined by the safety contour

- Isolated dangers which lie within the safe water defined by the safety contour, such as fixed structures, overhead wires, etc.
- Scale, range and north arrow
- Units of depth and height
- Display mode

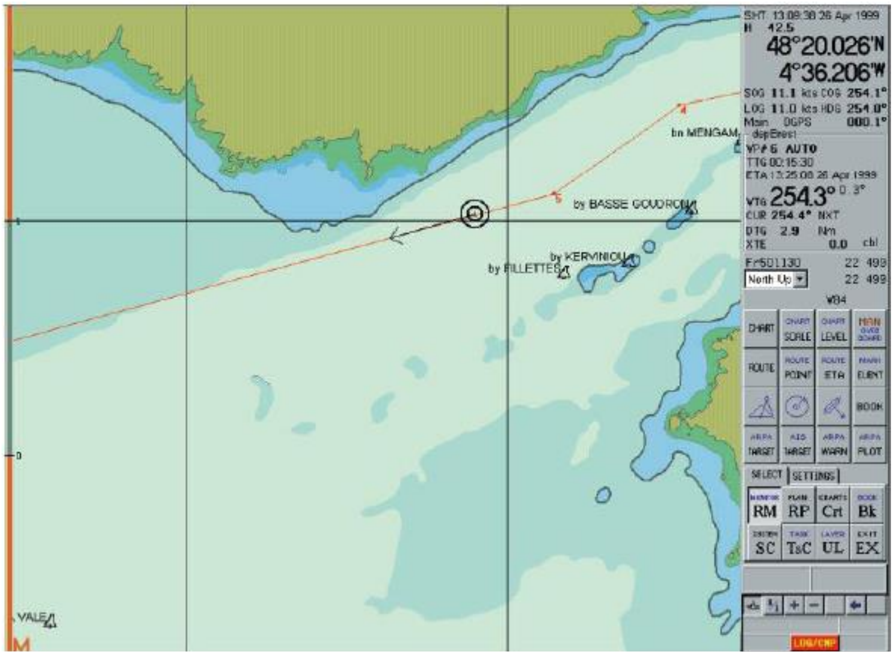


Figure 2.1: Base Display, by Day

- **Standard display**

The scope of information can be changed by the Watch Officer according to his wishes. In normal operation, the ‘Standard Display’ may be used as appropriate ECDIS display for navigation. The ‘Standard Display’ determines which SENC data will be displayed when the system is switched on. It consists of:

- The display base, as defined above
- Drying line
- Buoys, beacons, other aids to navigation and fixed structures
- Boundaries of fairways, channels, etc
- Visual and radar conspicuous features
- Prohibited and restricted areas
- Chart Scale boundaries
- Indication of cautionary notes
- Ships’ routeing systems and ferry routes
- Archipelagic sea lanes.

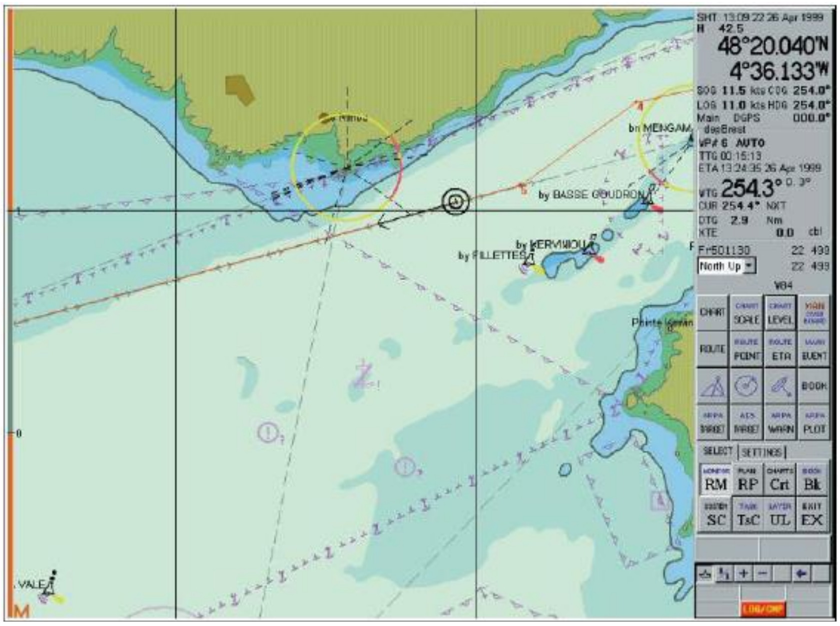


Figure 2.2: Standard Display, by Day

Figure 2.3: Standard Display, by Night

- **Display on request**

Display on request provides various detailed navigational information available in the SENC on query. All other information, to be displayed individually on demand are listed in appendix 2 of the Revised Performance Standards for ECDIS Res.MSC232 (82). This display can be easily overloaded with objects.

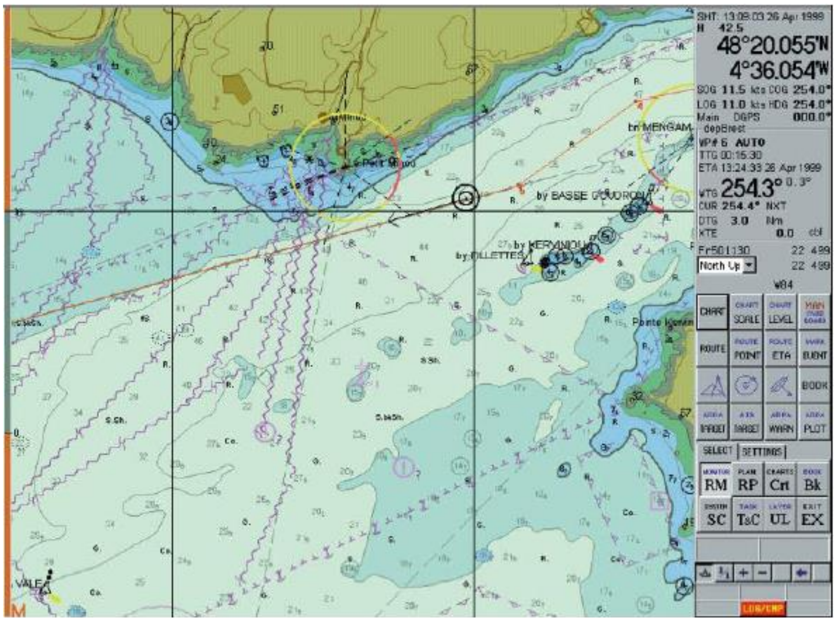


Figure 2.4: Full Display, by Day; an example of display on request

All Other Information consists of:

- Submarine cables and pipelines
- Details of all isolated dangers
- Details of aids to navigation
- Contents of cautionary notes
- ENC edition date
- Most recent chart update number
- Magnetic variation
- Graticule
- Place names

Some systems allow to select certain information layers individually (e.g. spot soundings, ferry routes, cables, etc.) instead by 'category call'. The user can switch from one display category to another and if the need be, add or remove additional objects. The category in use is always indicated. At any time, it must be possible to return to the 'Standard Display' with a single operator action. This is especially important when a chart is overloaded with information, or when a 'Display base' has been called up and some important information is missing.

2.3: Information Types and Areas on Navigation Display

ECDIS Display

ECDIS is an intelligent dynamic navigational system designed to improve the safety and efficiency of navigation. ECDIS integrates various navigational information, including chart information, positional information, and other data derived through the sensors and equipment onboard, to provide display of various navigational details, comprising dynamic display of the vessel. The system also provides audio-visual alarms while approaching danger or malfunctioning of equipment.

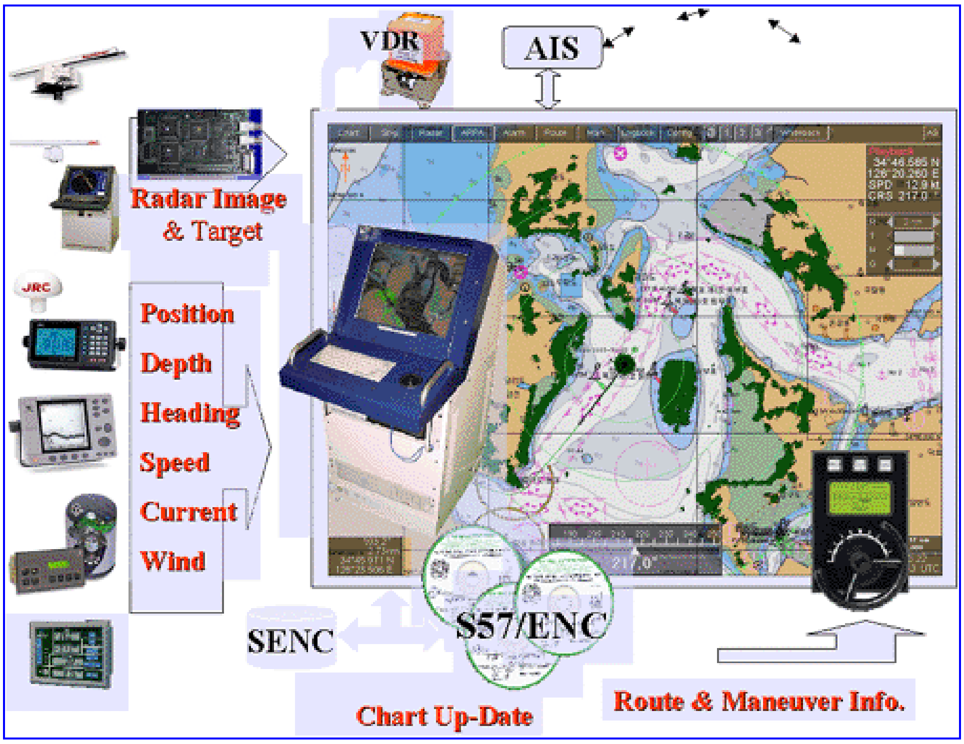


Figure 2.5: ECDIS integrates various navigation information

2.3.1: Overview

The ECDIS (Electronic Chart Display and Information Systems) is fitted with color display and its screen is divided into several areas. This display presents chart images, symbols, and various on-screen data such as heading, speed, etc. The Status bar, which is always shown at the top of the screen, mainly displays equipment status. The boxes at the right side of the screen comprise the Information areas. They are permanently displayed and show information such as your ship's position, alerts generated by the system, workstation mode and cursor position. The operator may display the data of his or her choice in one of the information areas called a Sidebar. The bottom block in the information area is the Mouse functions area, and it shows the current left mouse button, scroll wheel and right mouse button functions, in that order from left to right.

7/8 of the ECDIS display is taken up by the **Electronic chart area**.

(1) Presentation mode
(2) ECDIS mode
(3) Display scale
(4) Chart only switch
(5) Name of display settings (Base, PartStd, Std, All Other)*
(6) Radar selection (TT/radar video source)

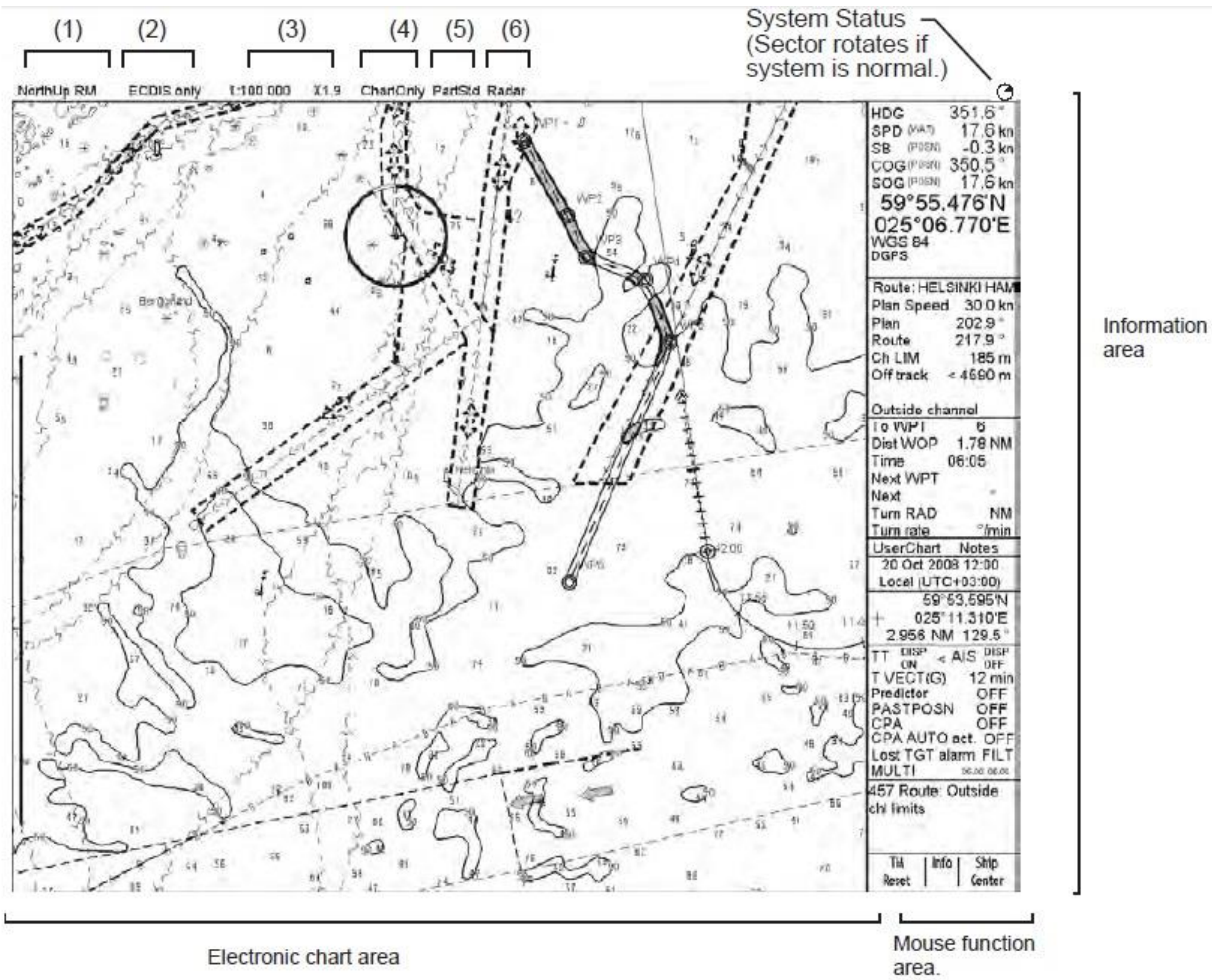


Fig. 2.6: Parts of the ECDIS display

❖ Status Bar (Top Bar)

The status bar is located at the top of the Display area. Its main purpose is to indicate the status of the equipment (ECDIS).

❖ Information Area

The information area displays details about your ship's position, course and speed and the cursor's location on the chart.
Information from the positioning sensors:

- HDG heading and its source if it is not true gyro.
- SPD water speed
- SB, Transversal speed, positive value to Starboard.
- COG (Course over ground) and its source
- SOG (Speed over ground)
- Latitude and longitude position of own ship
- Datum in use (WGS 72, WGS 84, European 1950, etc.), which is shown above positioning source.
- Positioning source: Dead Reckoning, GPS, DGPS, LORAN, FILTER, etc.
- Latitude and longitude position of cursor displayed in selected datum.

- Range and bearing from your ship's position to cursor

Note: The order of items in the position and cursor windows can change with the sidebar used. See the next page.

❖ Sidebar

Sidebar is the part of the display that offers additional information aside from the data which are being provided by the Information Area. It is found in the right side of the display along with the Information Area. The user has the option to select what kind of information to be displayed from the options shown below. The content of the sidebar windows change with the devices and sensors connected to the system. The route display or autopilot display is always displayed. You can display one of them together with the conning display, docking display or chart legend. When two sidebars are active, the width of the information area is doubled, as shown in the figure below.

.

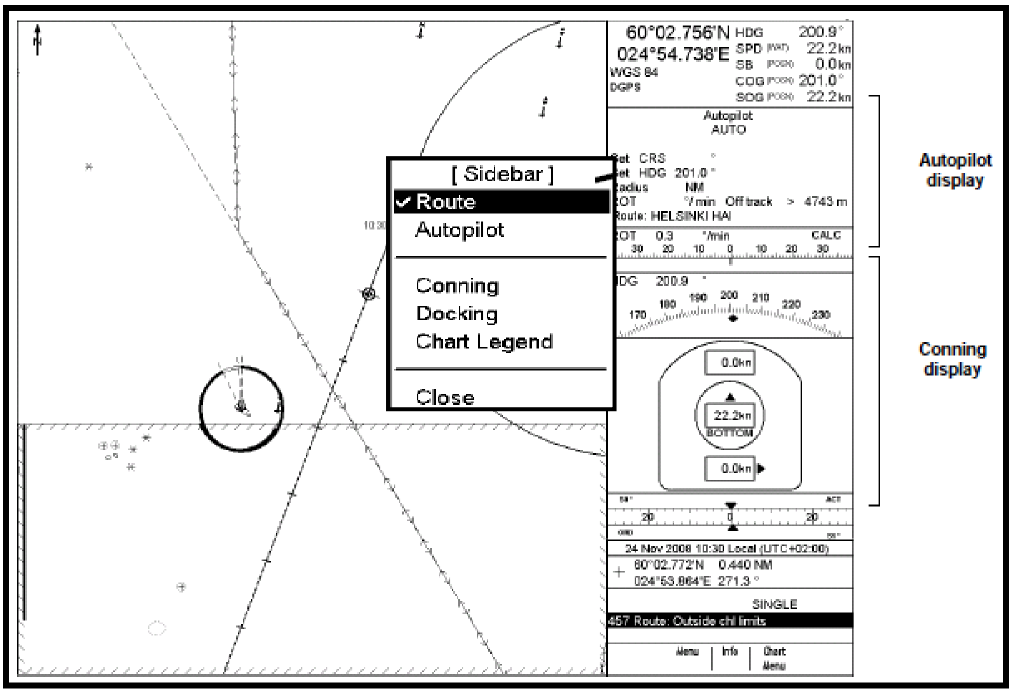


Fig. 2.7: Sidebar, with autopilot and conning display window

- ➢ Route display – contains information such as, plan speed, plan, route, channel limit, off track, next WP, Dist. to WOP, time to go to WOP, next planned course, turning rad., and turning rate.
- ➢ Autopilot display – contains information such as, steering mode, program course, set course, set heading, radius, and ROT.
- ➢ Conning display – contains information such as, ROT indicator, heading indicator, speed indicator, and rudder angle indicator.
- ➢ Docking display – contains information the same with the conning display except that it also indicate depth below transducers (on bow and on stern).
- ➢ Chart legend – provides various data about the chart currently displayed such as, cell name, nav. purpose, issue date, edition nos., last displayed update, update issue date, last update appl. date, projection, horizontal datum, vertical

datum, sounding datum, quality of data, magnetic var., unit of depth, and unit of height.

❖ **Alarms and Message Area**

The alarms and message area is to be found at the lower right corner of the display area. It displays the alarms that the system is receiving. And when required, it also conveys additional information to the user when utilizing a certain function.

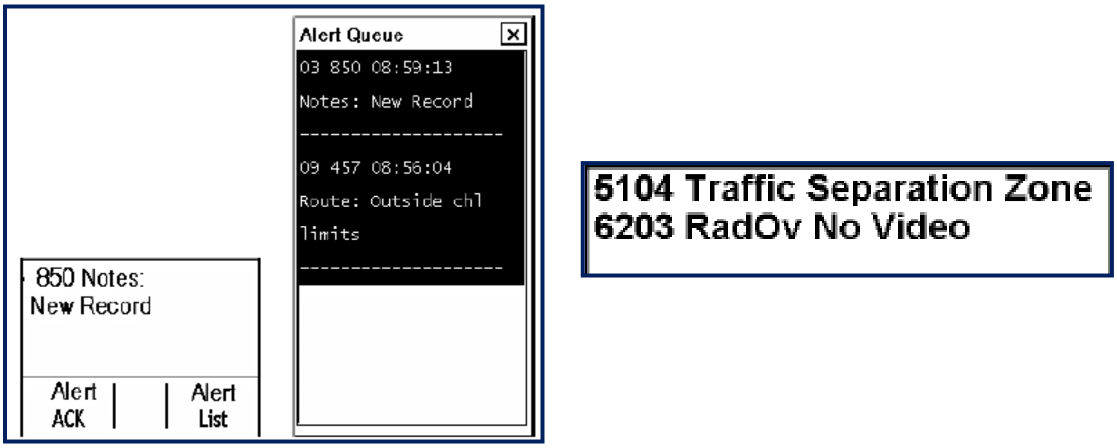
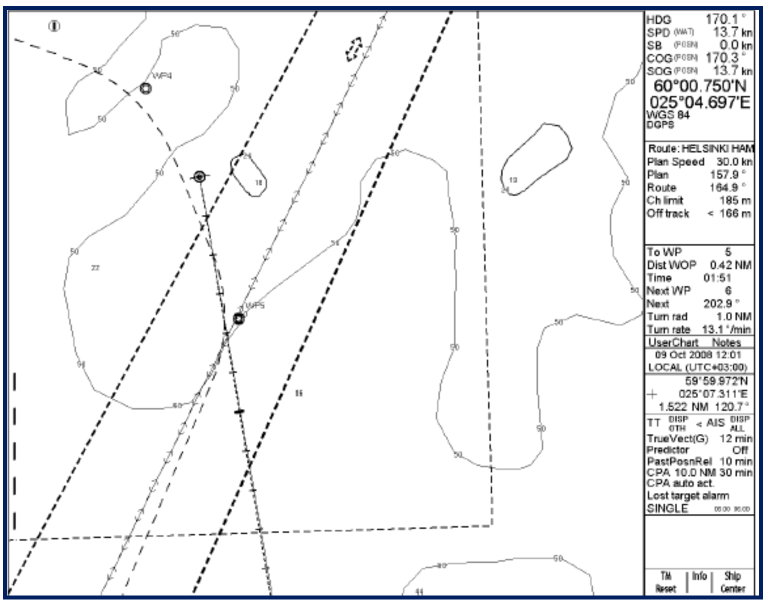


Fig. 2.8: Samples of presentation of ECDIS Alarms and Message

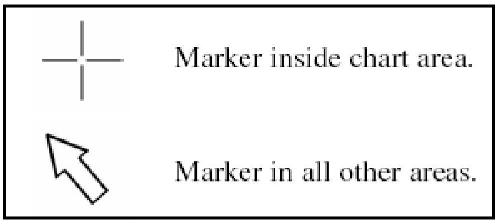
2.3.2: Electronic Chart Area (Chart Display)

This area comprises about 87.5 percent of the display area of an ECDIS. This window provides the electronic representation of a certain geographical area. It displays information such as land-water boundaries, depth, contours, light and its characteristics, vessel's position, and other more information as required by the operator. It is the workplace for developing, executing, and monitoring the passage plan / route.



❖ Trackball marker

The trackball is the system's pointing device and is referred to as the marker control. Together with the three associated keys it is used to control the chart and its display. Two different markers are;



❖ Tools

• EBLs/ VRMs

The Electronic Bearing Lines (EBL) and Variable Range Markers (VRM) are available and can be displayed simultaneously. EBL and VRM always appear in pairs. A number at the base of the EBL identifies the pair.

An EBL/VRM pairs centered on the own ship will move with own ship, while an offset pair will be geographically fixed.

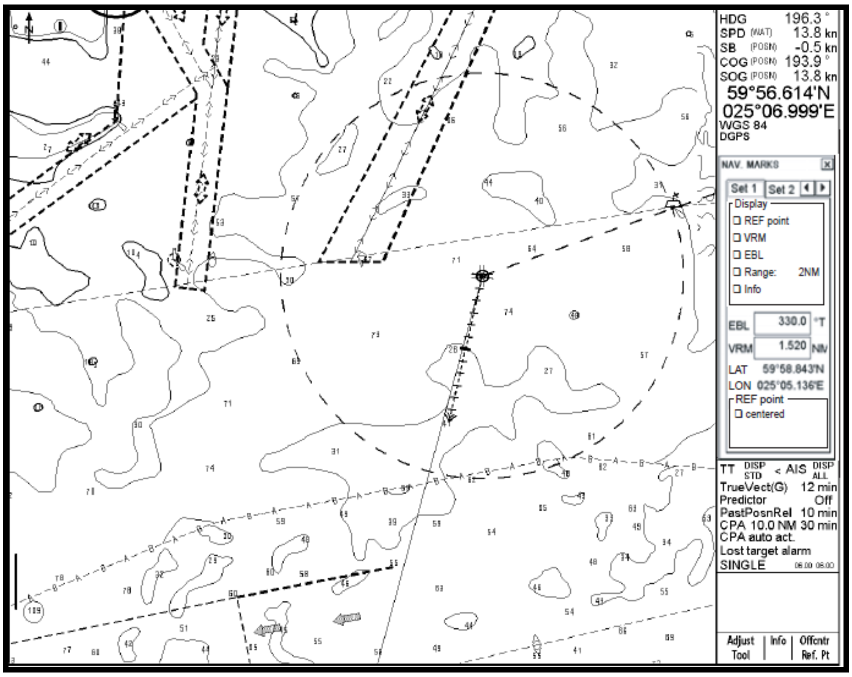


Figure 2.9: Editing EBL/ VRM

• Parallel index lines

Four parallel index lines are available. A number at the middle of the line identifies it when it is selected. Parallel index lines are either parallel to own ship heading (relative mode) or have a fixed orientation independent of own ship heading (true mode). In relative mode the parallel index lines follow the heading line when the own ship changes course. In true mode the bearing of the parallel index lines are geographically fixed. In both modes, the distance to own ship is constant.

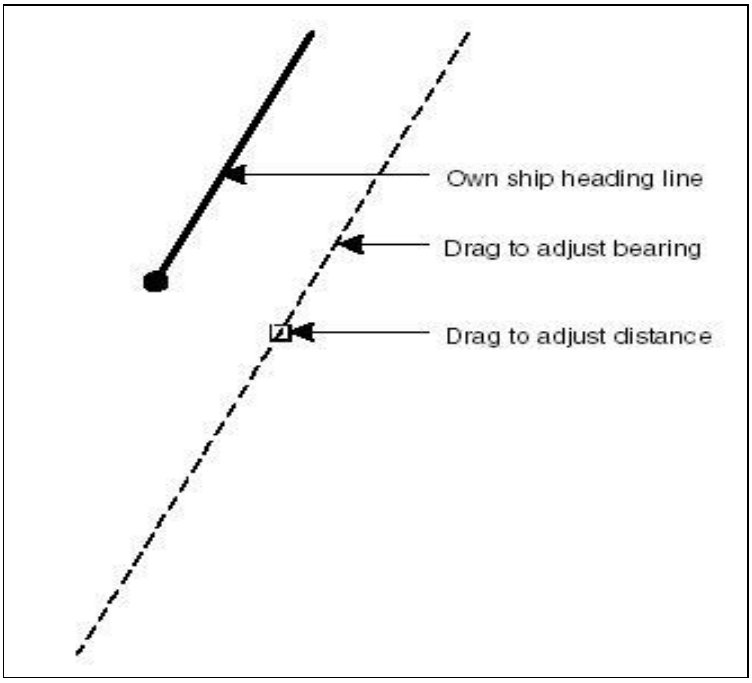


Figure 2.10: Parallel Index Lines

• Curved EBL

The curved EBL is a tool to plan and execute a turn using a fixed turn radius. The Curved EBL can be operated in two modes, ”Autopilot” and ”Planning”. In Autopilot mode, the turn will be executed immediately, while you can specify a time and distance to maneuver in planning mode.

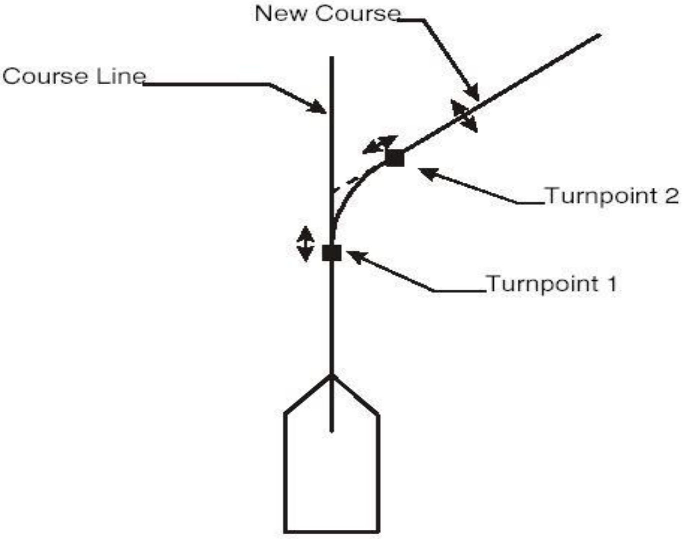


Figure 2.11: Curve EBL

❖ Mariner’s notes

Notes are navigation related notebook. It is a notebook data file that provides messages for the operator relative to a specific ship position in the monitoring mode. The operator specifies range for each Notes record. The ECDIS compares Notes range and your ship's position and displays Notes when your ship goes within the range set for the NOTES.

The operator may assign a brief message that will appear on the radar display together with the notice of the proximity of the relevant point.

While the ship sails, notebook pages (=records) in the selected Notes file are compared with your ship's position once per minute to select Notes. Further, when the ship has passed a waypoint, the system will make a comparison against your ship's position. If the system finds that you have arrived within a new Notes notebook page, it generates the alert "850 Notes: New Record".

There are four different variations as examples of how notes are presented on the chart area:

1. Position marker
2. Position marker and text
3. Position marker and range marker
4. Position marker, text and range marker

❖ Events and Man Overboard (MOB) functions

The EVENT is recorded into the systems voyage log as an occurrence or incident and can be referred to as a logbook. The EVENT dialog box appears, where you can write a comment (up to 48 alphanumeric characters) for an event. The comment is displayed only in the electronic chart area if Events is selected for display in the Tracking page of the Chart Display dialog box.

- User Event: display event symbols on ECDIS, where the system has recorded an event based on conditions you have set (Type: User and Auto).
- Auto Event: display automatically entered event symbols, where the system has recorded an event based on conditions you have set (Type: Ship and Alarm).

The MOB (Man Overboard).
(Position, etc. at time of man overboard are recorded to the logbook and MOB mark is displayed on the screen.

❖ Other function of ECDIS

Radar information and/or AIS information may be transferred from systems compliant with the relevant standards of the Organization. Other navigational information may be added to the ECDIS display. However, it should not degrade the displayed SENC information and it should be clearly distinguishable from the SENC information. Additionally, it should also be possible to remove the radar information, AIS information and other navigational information by a single operator action.

1. Display of Radar Information

- In Navigation Mode the radar image has the highest display priority and it is only allowed to be presented in the relative motion, head-up mode.

- The underlay SENC match in position, range and orientation. The radar image and the position from the position sensor are both adjustable for the antenna offset to the conning position.
- The overlaid radar-image contains additional navigational information.

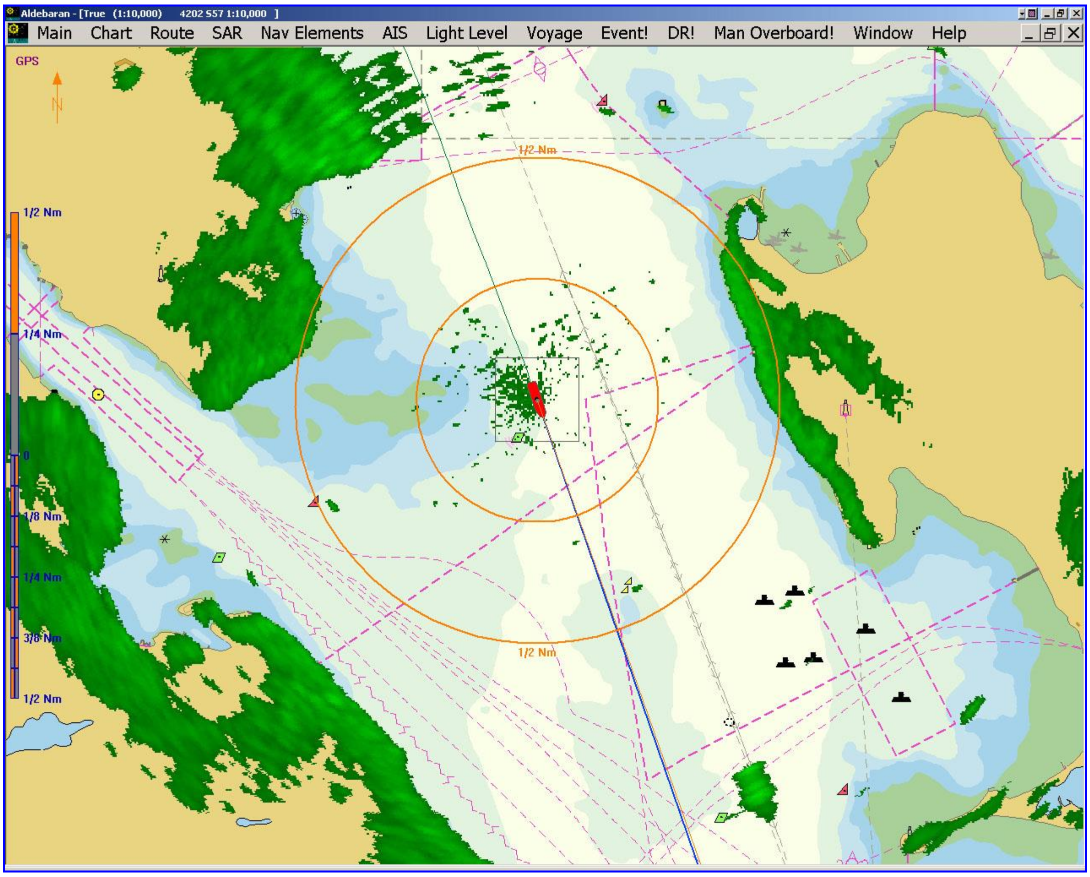


Figure 2.12: RADAR overlay on North up presentation

2. ARPA

- ARPA targets from up to 3 sources can be displayed simultaneously.
- Up to 100 targets from each source can be displayed.

For each target the following information is stored:

- Source and ID.
- Time of observation.
- Range and bearing (absolute) from own ship.
- Position
- Speed
- Course (true)
- Target status (Tracked/acquired/lost/TCPA warning etc).
- Textual target ID
- TCPA (only for inquiry)
- CPA (only for inquiry)

3. Display of Other Navigational Information

- ECDIS and additional navigational information use a common reference system.

- It is possible to display the own ship's position on the screen.
- It is possible for the master to select safety limits.
- ECDIS emphasize the falling short of the safety limits.

4. Functions with Immediate Access

The following operational functions which have direct access:

- RANGE
- BRILLIANCE
- COLOURS
- INFORMATION DENSITY

These functions need either own control elements or own menu areas, which are arranged in the highest menu level and are permanently visible

5. Permanent Visible Function Parameters

The following function parameter those are always visible:

- actual RANGE
- sensor STATUS
- selected WATERLEVEL (if available)
- selected SAFETY DEPTH (if available)
- selected INFORMATION DENSITY

6. Automatic Track Keeping

When the system is interfaced to a Track Pilot, programmed routes can be used to steer the ship. Track Pilot sends course, upcoming turn radius and new course, off-track distance etc. to the autopilot. The autopilot adjusts the steering accordingly. The autopilot can be controlled in four modes:

- **Heading Mode**: The heading set-point for the ship is used as the course to steer. *No route required*.
- **Course Mode**: The course set-point and the calculated drift are used to calculate the heading to steer. *No route required*.
- **Waypoint Mode**: The route and the calculated drift is used to calculate the heading to steer. The system compensates for cross track error in order to reach the waypoint. Waypoint mode is selected for one waypoint at a time. When the ship is close to the waypoint, the mode is changed to Course mode to avoid large course changes close to the Waypoint. Turns must be started manually.
- **Track Mode**: The system steers the ship according to the programmed route with a minimum of cross track error (XTE), a minimum of course alterations and optimum rudder usage. In this mode turns are executed automatically.

7. SAR (Search and Rescue)

This application serves for planning of search and rescue operations. By just inputting data of the coordinates and speed of own ship and coordinates of people in distress you receive a choice of 3 search patterns (most used in navigation). Those patterns are represented as route plans with a subsequent WP you have to proceed while SAR operation.

Figure 2.14: SAR operation

8. Own Ship Data Calculation

- Parallel navigation sensor integration filters with sensor deviation monitoring.
- Calculated position and sensor input values distributed via LAN in integrated systems for improved reliability.
- Manual input of offset to calculated position.
- Automatic or manual selection of navigation sensor input to navigation filter.
- Own ship past track calculation.
- Alternative manual course, speed, set and drifts input.

2.4: Presentation of ECDIS data

The symbols for ECDIS are based on the familiar paper chart symbols, with some optional extras such as simplified buoy symbols that show up better at night. Since the ECDIS can be customized to each ship's requirements, new symbols were added such as a highlighted, mariner selectable, safety contour and a prominent isolated danger symbol.

The Presentation Library is a set of colors and symbols together with rules relating them to the digital data of the ENC, and procedures for handling special cases, such as priorities for the display of overlapping objects. Every feature in the ENC is first passed through the look-up table of the Presentation Library that either assigns a symbol or line style immediately, or, for complex cases, passes the object to a symbology procedure. Such procedures are used for objects like lights, which have so many variations that a look-up table for their symbolization would be too long.

The Presentation Library includes a Chart 1(The Admiralty chart 5011 equivalent), illustrating the symbology. Given the IHO S-57 data standards and S-52 display specifications, a waterway should look the same no matter which hydrographic office produced the ENC, and no matter which manufacturer built the ECDIS**.**

The overwhelming advantage of the vector-based ECDIS display is its ability to remove cluttering information not needed at a given time. By comparison, the paper chart and its raster equivalent is an unchangeable diagram. A second advantage is the ability to orient the display course-up when this is convenient, while the text remains screen-up.

Flexibility in display scale requires some indication of distance to objects seen on the display. Some manufacturers use the rather restrictive but familiar radar range rings to provide this, while another uses a line symbol keyed to data's original scale. The ECDIS design also includes a one-mile scale bar at the side of the display, and an optionally displayed course and speed made good vector for own ship. There may be a heading line leading from the vessel's position indicating her future track for one minute, three minutes, or some other selectable time.

Display options for ECDIS include transfer of ARPA acquired targets and radar image overlay. IMO standards for ECDIS require that the operator be able to deselect the radar picture from the chart with a single operator action for fast "uncluttering" of the chart presentation.

Product Specification of S-57

Production of ENC data must be in accordance with rules defined in the Product Specification of S-57 and must be encoded using rules described in object and attribute catalogue. The main points are as follows:

- A cell is a geographical area containing ENC data and it must be rectangular
- Navigational purpose of the cell must be defined such as overview, general, coastal, approach, harbor and berthing.
- An ENC cell can not have inset (it will be created as a separate cell).
- An ENC of same navigational purpose may overlap but not duplicate data in the overlap area (even if multiple producers are involved).
- Objects on the border of adjoining cell must remain only in one cell.
- The geographic extent of the cell must be chosen by the ENC producer nation to ensure that the data file must not contain more than 5 Megabytes of data and cell size must not be too small.
- Topology must be in chain mode.
- Horizontal datum must be WGS-84
- Projection is not used.
- Units to be used are:
- Position: Lat. and Long. in decimal degrees
- Depth in meters
- Height in meters
- Positional accuracy in meters
- Distance in nautical miles
- Feature objects id's must be unique worldwide except where it crosses cells or usages.
- Feature object id's must not be re-used even after deletion of object.
- Mandatory, prohibited and optional geo, meta and collection objects to be followed as per specification.
- Cartographic objects like area, line, Csymb, Comps & text are prohibited.
- No user defined object classes, attributes or attribute values are to be used.

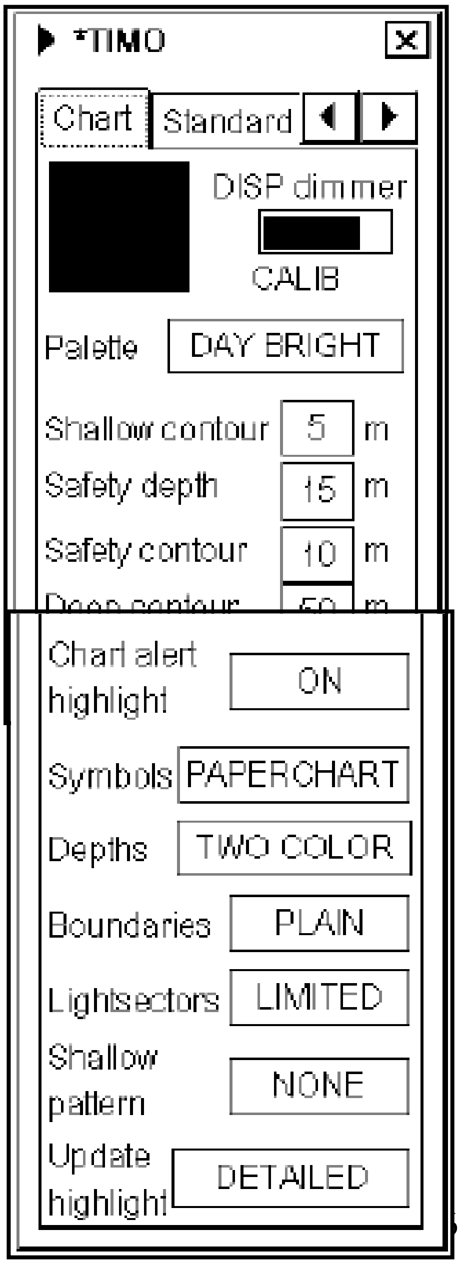
- The relationship between objects is made using master and slave concept, and using collection objects, such as light over tower
- Feature objects must belong to one of two groups:

All the feature objects of a chart can be classified in to four categories to enable efficient exchange of non-locational description of real world entities -

1. Metadata is a feature object which contains information about other objects
2. Cartographic Objects are feature objects which contain information about the cartographic presentation of real world entities (including text) this object is prohibited to be used in S-57 Edn. 3.1.
3. Geodata is a feature object which carries the descriptive characteristic of a real world entity Collection –
4. Object which describes the relationship between other objects.
   Group 1 - Skin of Earth
   Group 2 - All feature objects which are not in Group 1 are in Group 2.

Chart page

Black and grey color symbol:
This symbol is used to verify that you can distinguish black (frame of symbol) and grey (inner part of symbol) colors with current contrast and brilliance settings.



Dsp Dimmer:
Use this control to adjust dimming of display.

Note: Use of the brightness control may inhibit visibility of information at night.

Palette:
Select appropriate palette for the display depending on the brightness of the bridge.

Shallow contour:
Set value of shallow water contour.

Safety depth:
Set value of safety depth. Spot soundings below the safety depth are highlighted.

Safety contour:
Set value of safety contour. Visible safety contour is equal to set value or if the contour of set value is not available then the visible safety contour is next deeper contour than safety contour.

Note: The system uses safety contour also for chart alerts.

Deep contour:
Set deep water contour.

TM reset:
In the true motion mode, own ship moves until it reaches the true motion reset borderline (set here), and then it jumps back to an opposite position on screen based on its course. Set the limit for TM reset (in percentage).

Chart alert highlight: Enable or disable highlight of chart alerts.
Symbols:
Select how to display chart symbols. The options are:
1. **Simplified:** The shape of symbols is of modern design and the sea mark symbols are filled in a color.
2. **Paper Chart:** The shape of symbols imitates traditional symbols used in paper charts.

2.4.3: Modes of Presentation

There are two possible modes of display, **relative** and **true**. In the relative mode the ship remains fixed in the center of the screen and the chart moves past it. This requires a lot of computer power, as all the screen data must be updated and re-drawn at each fix. In true mode, the chart remains fixed and the ship moves across it. The operator always has the choice of the north-up display. On some equipment, the operator can select the course-up display as well. Each time the ship approaches the edge of the display, the screen will re-draw with the ship centered or at the opposite edge.

A separate monitor or a window in the navigation monitor can be used for display of alpha-numeric data such as course, speed, and cross-track error. It can also be used to display small scale charts of the area being navigated, or to look at other areas while the main display shows the ship's current situation.

Chart display mode: Push the button to bring up the **Display Mode** menu. This menu allows you to select between the following monitoring modes:

- NUP/TM - north up true motion
- NUP/RM - north up relative motion
- CUP/TM - course up true motion
- CUP/RM - course up relative motion
- HUP/RM - head up relative motion

These modes are used for monitoring the ship in relation to the chart. The system will automatically update the display to follow the ship's movement.

ECDIS Units

The following units of measure will appear on the ECDIS chart display:

• **Position** **:** Latitude and Longitude will be shown in degrees, minutes, and decimal minutes, normally based on WGS-84 datum.

• **Depth** **:** Depth will be indicated in meters and decimeters.
Fathoms and feet may be used as an interim measure only:
- when existing chart data is held in those units only,
- when there is an urgent need for an ENC of the applicable area, and
- time does not allow for an immediate conversion of the English units to their metric equivalents.

• **Height** **:** Meters (preferred) or feet.

• **Distance** **:** Nautical miles and decimal miles, or meters.

• **Speed** **:** Knots and decimal knots.

Priority Layers

ECDIS requires data layers to establish a priority of data displayed. The minimum number of information categories required and their relative priority from the highest to lowest priority are listed below:

- ECDIS Warnings and Messages.
- Hydrographic Office Data.
- Notice to Mariners Information.
- Hydrographic Office Cautions.
- Hydrographic Office Color-Fill Area Data.
- Hydrographic Office On Demand Data.
- Radar Information.
- User's Data.
- Manufacturer's Data.
- User's Color-Fill Area Data.
- Manufacturer's Color-Fill Area Data.

IMO standards for ECDIS will require that the operator be able to deselect the radar picture from the chart with minimum operator action for fast "uncluttering" of the chart presentation.

CH. 3: VALUE TO NAVIGATION

3.1: Factors that characterize and modify chart Presentation

- Projection
  - The concept of depicting a three-dimensional object, such as the Earth, on a plane sheet is known as a *projection* in the cartographic world. Mathematicians commonly use the term *mapping*, and they have extended the concept into multiple dimensions, leading to important discoveries in fields well beyond cartography.
  - If points on the surface of the sphere are projected from a single point, the projection is said to be **perspective** or **geometric**.
  - As the use of electronic charts become increasingly widespread, it is important to remember that the same cartographic principles that apply to paper charts apply to their depiction on video screens.
  - Mariners most frequently use a **Mercator projection**, classified as a **Cylindrical projection** upon a plane, the cylinder tangent along the equator. Similarly, a projection based upon a cylinder tangent along a meridian is called **transverse** (or inverse) **Mercator** or **transverse** (or inverse) **orthomorphic**. The Mercator is the most common projection used in maritime navigation, primarily because rhumb lines plot as straight lines.
  - On many systems the projection will be fixed by the manufacturer and be unchangeable. It is required that the projection in use is included within a

standard legend of information relating to the area displayed. On some equipment, there may be facilities for the user to select between projections. This may be useful, for instance, if voyaging at high latitudes when the use of a polar stereographic projection may be appropriate. No particular projection is required and it is possible that the projection will not be standard Mercator.

- Color and Intensity
  - The colors used for the presentation of alphanumeric data, text, symbols and other graphical information should provide sufficient contrast against the background under all lighting conditions likely to be experienced on the bridge of a ship.
  - The colors and brightness should take into account the light conditions of daylight, dusk and night. The presentation should support night viewing by showing light foreground information on a dark non-reflecting background at night.
  - The background color and contrast should be chosen to allow presented information to be easily discriminated without degrading the color coding aspects of the presentation.

MAGENTA

- **MAGENTA TINT** may be used in congested areas where it is important not to obscure black detail, and for specific symbols such as Traffic Separation Zones, Particularly Sensitive Sea Areas and Archipelagic Sea Lanes.

BUFF (YELLOW) OR GREY

- A color, usually buff or grey, must be used as a land tint. If the minimum four colors are used, the color may be carefully selected so that a satisfactory color over inter-tidal areas is derived from printing the land tint over the shallow water blue tint.

BLUE

- The color blue must be used as a tint to emphasize **shallow water.** Two (or more) densities of blue tint may be used to show different depth bands of shallow water, the darkest tint showing the shallowest water. The blue tint may be combined with that used for land, as described in B-143, to produce an appropriate colour for inter-tidal areas. Blue may also be used for depth contours, particularly in intricate waters.

GREEN

- The color green may be used as a tint for **inter-tidal areas.** This may be achieved by combining the land color with the shallow water blue color. Green may also be used, instead of magenta, for environmental information and limits.

CAUTIONARY NOTES - COLOUR

- Cautionary notes must normally be shown in the same color as the charted features to which they refer. An exception is that referring to differences between horizontal datums on adjoining or different scale charts, where the note is in black (as it refers to positions) and the legend ‘see Note’ is in magenta (as chart limits and references are in magenta).
- If a note refers to two or more features which are charted in different colours, the note should be in the color of the most navigationally significant feature. For example, when a note about an Environmentally Sensitive Sea Area

(charted in green) is combined with a magenta note (e.g. about an associated restriction), then the entire note should be in magenta.

- Symbols
  - Symbols used for the presentation of operational information are defined in IMO SN/Circ. 243.
  - Symbols used for the display of charted information should comply with relevant IHO standards.

3.2: Factors that characterize and modify data quality

Data Quality - refers to the degree of excellence exhibited by the data in relation to the portrayal of the actual scenario.

- Accuracy
  - The degree of conformance between the estimated or measured value and its true value.

- Resolution
  - The smallest difference between two adjacent values that can be represented in a data storage, display, or transfer system.

- Completeness
  - The degree of confidence that all of data, needed to support the intended use, has been provided.

3.3: Manually change scale, area & position of ownship

You may view S57 or ARCS charts using different positions and different scales. The basic tools for browsing charts are **Range -, Range+, Set Chart Center, Ship Offcenter** and **TM Reset**.

Activate Scroll allows you to look ahead from a place other than own ship's current position.

Set Chart Center allows you to look ahead from a place other than own ship's current position.

Range - and **Range +** change the chart scale. If true motion reset is active, ZOOM IN and ZOOM OUT keep the relative position of your ship with respect to the display. If true motion reset is on, ZOOM IN and ZOOM OUT keep the relative position pointed by the cursor with respect to the display.

The system automatically selects next larger or smaller scale. If a chart with larger compilation scale is available at your current viewing position, the message "Larger Scale Data Exists" appears.

If the indication "Equal RNC" appears, this means that you have a chart with the same scale and overlapping with the displayed ARCS chart. When you reach an edge of a chart and the indication "Equal RNC" appears, this means you can switch to another chart with the same scale to the display by displaying Edit Insert/Info/Select Next in the mouse functions area and pushing the right mouse button. An overlapping chart with the same scale will be opened.

Looking for Charts around Own Ship

You can use either true motion or relative motion. In the true motion mode, own ship moves until it reaches the true motion reset borderline, where it jumps back to an opposite position on the screen based on ship's course. In the relative motion mode, own ship stays in a fixed position, while the chart moves on screen.

If, in the true motion mode, you reset own position with TM Reset, own ship will immediately jump to the true motion reset position.

If, in the true motion mode, you use Ship offcenter, your ship will go to that position on screen and continue true motion movement from that position. When it reaches the true motion reset borderline, it will automatically jump to the true motion reset position.

If, in the relative motion mode, you reset own position with TM Reset, your ship will immediately jump to the true motion reset position and use that position as fixed position to stay on screen.

If you use relative motion, you can select a new fixed position for your ship by using Ship off center.

Use **Range -** and **Range+** to select desired chart scale.

3.4: Evaluate the route monitoring mode of ECDIS operation

❖ **Route Monitoring Mode**

Route monitoring is basically comparing the progress of the voyage against the pre-prepared plan and monitoring the safety of any necessary deviations from the plan. These deviations may be because of collision avoidance action or any other tactical maneuvers, to maintain safety or react to specific requests from coastal authorities. And during route monitoring, ECDIS must show own ship's position whenever the display covers that area. Although the mariner may choose to "look ahead" while in route monitoring, it must be possible to return to own ship's position with a "single operator action". Key information provided during route monitoring includes a continuous indication of vessel position, course, and speed. Additional information that ECDIS can provide includes such information as distance right/left of intended track, time-to-go (time-to-run), distance-to-go (distance-to-turn), position and time of "wheelover", and past track history.

Route monitoring is permanent mode running concurrently with other operation modes, it produces most important information for navigator while sailing. The "ECDIS Performance Standard" requires not only that the planned route is checked prior to the start of the voyage but also that the vessel's position is checked during the voyage in relation to the planned route and the surrounding dangers. In order to safeguard against the risk of grounding, a position monitoring system shall enable detection of cross-track error in relation to the pre-planned route and release an alarm at a time to danger of grounding which allows for proper and effective action to be taken by the back-up officer.

ECDIS is more than an anti-grounding tool, e.g. its motion prediction facility allows the mariner to see the position of the vessel within the next few minutes. This prediction is not a simulation. It is simply an extrapolation of the actual motion parameters and therefore applicable for all types of vessels – from the smallest pilot launch to the largest super tanker.

The ECDIS provides the navigator with all tools necessary to monitor the progress of the voyage. In addition to continuously updated information about position, heading and speed, past positions (at selectable intervals) with time stamps can be obtained by the navigator at will. Additionally route related information like cross track error (XTE), time and distance to the next waypoint etc. are continuously calculated and graphically displayed.

The information area displays the data on the ship's position relative to the monitored route. The monitored route consists of the following information, displayed in the electronic chart area:

- The route is displayed with red thick long dashed line.
- The limits of channels of each leg are displayed with solid red lines. These limits are used to detect chart alerts when you are monitoring the route.
- Each leg has information about planned speed.
- Each leg has information about planned course to steer.

❖ **Navigation Mode**

Navigation Mode means the use of the Inland ECDIS for conning the vessel with overlaid radar image.

(a) **Navigation Mode** means the use of the Inland ECDIS for conning the vessel with overlaid radar image. The radar information shall be clearly distinguishable from the SENC information.
(b) **Inland ECDIS** means an electronic chart display and information system for inland navigation, displaying selected information from an Inland System Electronic Navigational Chart (Inland SENC) and, optionally, information from other navigation sensors.
(c) **Inland System Electronic Navigational Chart (Inland SENC)** means a database resulting from the transformation of the Inland ENC by Inland ECDIS for appropriate use, updates to the Inland ENC by appropriate means and other data added by the skipper. It is this database that is actually accessed by the Inland ECDIS for display generation and other navigational functions. The Inland SENC may also contain information from other sources.
(d) The integrated display shall be in accordance with the requirements for radar on inland waterways as specified in its technical specifications.
(e) The chart and the radar image shall match in size, position and orientation within the limits as specified in its technical specifications.

(f) The Integrated Display shall only be presented in the head-up orientation. Other orientations are permitted in systems with an additional maritime ECDIS type approval. If such a system is used in true motion and/or north-up mode on European inland waterways, it is considered to be working in **information mode**.
(g) It shall be possible for the operator to adjust the off-set values between the positions of the position sensor and the radar antenna of the vessel so that the SENC display matches the radar image.
(h) It shall be possible to remove either the ECDIS or the radar information by a single operator action temporarily.
(i) The vessel's position shall be derived from a continuous positioning system of which the accuracy is consistent with the requirements of safe navigation.
(j) **Navigation mode** shall provide an indication when the input from the position-fixing system is lost. **Navigation mode** shall also repeat, but only as an indication, any alarm or indication passed to it from a position fixing system.
(k) The positioning system and the SENC shall be based on the same geodetic datum.
(l) In **navigation mode**, at least the following features shall be included in the ENC and shall not be obscured by other objects:

- bank of waterway (at mean water level)
- shoreline construction (e.g. groyne, longitudinal control dam, training wall – any facility that is considered a hazard to navigation)
- contours of locks and dams
- boundaries of the fairway / navigation channel (if defined)
- isolated dangers in the fairway / navigation channel under water
- isolated dangers in the fairway / navigation channel above water level, such as bridges, overhead cables etc.
- Official aids-to-navigation (e.g. buoys, beacons, lights, notice marks)
- waterway axis with kilometres and hectometres or miles
- location of ports and transhipment sites,
- reference data for water level gauges relevant to navigation
- links to the external xml-files with operation times of restricting structures, in particular locks and bridges.

(m) Information regarding the position and orientation of other vessels, gathered by other communication links than the own radar, are permitted to be displayed only if they are up-to-date (nearly real-time) and meet the accuracy that is required for the support of tactical and operational navigation. Position information of the own vessel that is received from a repeater station shall not be displayed.
(n) As tracking and tracing information (for example AIS) of other vessels is useful for the planning of the passing, but of no use during passing itself, tracking and tracing (AIS) symbols shall not disturb the radar image during passing and shall be faded out therefore. Preferably the application shall allow the skipper to define the area where the symbol is faded out.
(o) The presentation of the position and the orientation of other vessels by a directed triangle or a true outline (to scale) are permitted only if the heading of these other vessels is available. In all other cases a generic symbol shall be used (an octagon is recommended, a circle shall not be used for applications which are certified according to maritime standards).

(p) Information that another vessel is carrying blue cones or lights may be displayed by a different colour of the vessel symbol. The number of the blue cones/lights shall only be displayed in the pick report.
(q) Information on the intention of another vessel to pass on starboard (blue sign) may only be displayed on the right side of the directed triangle symbol or of the scaled shape if the heading of this vessel is available. If no heading information is available the information shall only be displayed in a direction independent form.
(r) Information regarding the position of AIS base stations, AIS Aids to Navigation (ATON) and AIS Search and Rescue Transponder (SART) may be displayed, if the symbols can be distinguished from other symbols (e.g. symbols 2.10 and 2.11 of IEC 62288 Ed. 1, Table A.1).

3.5: Value of ECDIS to navigation

ECDIS primary function is to contribute to safe navigation but mariners should be aware that ECDIS is far more than a digital version of a paper chart. It allows for monitoring of a ship's position in real-time throughout the voyage and integrates information from GPS, gyro, radar, ARPA and AIS into a single display. ENCs also contain far more data than is available on a paper or rater chart.

On a traditional bridge, the watch keeper has to manage all the information available from these electronic aids to navigation, which may not be co-located on the bridge, as well as absorbing information from other sources such as fixed and floating aids to navigation. The information is used to plot the ship's position on the paper chart and the watch keeper must then make calculations based on the position, the course and speed made good since the previous plotted position and use tide, current and wind/weather information to plot the direction to take the vessel.

All this take times and in confined and congested waters, the stress level on the watch keeper and bridge team is increased. ECDIS is intended to reduce stress caused by the need to keep track of all information necessary to make the appropriate decisions and allow the officer of the watch to focus on making the right decisions in a timely and controlled manner. With ECDIS, the vessel's position is continuously displayed in real time rather than the historical position given by plotting on the paper chart.

The ECDIS concept is a total change from using paper charts and the transition from paper charts to electronic charts will pose some concerns for the industry, particularly for those who have no current experience of electronic charts. Important bridge procedures are significantly affected and these careful analysis and consideration. The experience of those who have been using electronic charts for some time show its use will reduce the navigational workload when compared to using the paper chart. This will enable the mariners to execute in a convenient and timely manner all voyage planning, monitoring and positioning that is currently performed on paper charts.

A further benefit for navigating officers is the automatic updating of electronic charts, thus relieving them of the tedious job of correcting charts and eliminating the risk of making errors when making these corrections.

The reduction in workload associated with navigating on paper charts however, must be taken into account when implementing operational procedures. Failure to instigate the discipline of being alert and engaged in the process of ECDIS navigation has proved to lead to distractions, complacency and ultimately accidents.

All of this new technology will be of very little benefit in enhancing navigational safety if the watch keeping officer is not fully trained and properly qualified in its use.

Benefits to Navigators

- **Reduced Workload**

Traditionally, most static information is printed and contained in a wide variety of navigational publications (e.g. light list or coastal pilot). More dynamic information had to be obtained using different types of equipment, often with differing operational procedures and output formats (e.g., GPS, radar/ARPA, and AIS). In contrast, an electronic chart bundles a variety of information together and graphically displays it all in a comprehensive image. The most visible advantage of the electronic chart is the simultaneous integration of both chart and navigation-related information; therefore reducing navigation workload. In turn, this allowed the Mariner to concentrate more on collision avoidance and overall situational awareness.

- **Display of Ship's Position in Real-time**

The automatic and continuous display of present position, heading, course, and speed of the vessel on the electronic chart display relieves the user from the time-consuming and error-liable routine of collecting and manual compilation of these data (i.e., manual plotting of navigation fixes), specifically it allows the Watch Officers to spend more time on the important task of lookout. For the first time in the history of marine navigation, the Watch Officer knows where he is at any moment, instead of where he was – some time ago.

- **Central Role at the Steering Station**

When an electronic chart system is installed at the steering station, the Watch Officer is provided with all the necessary information at a central workplace in the front of the bridge. He is no longer has to move from place to place, or from one instrument to another. Since the electronic chart automatically displays and continually assesses chart and navigation-related information, the Mariner can concentrate more on operating the vessel and on overall situational awareness. The electronic chart delivers to him a complete real-time image of the situation that is always current. When oriented in the direction of sailing, the display can be compared with what is occurring visually (e.g., course-up or head-up display).

- **Situation Dependent Display**

Using vector-based electronic chart data, the workload of a Mariner can be reduced by modifying the displayed chart image to the situation-at-hand. While a paper chart contains a fixed amount of information, the electronic chart display can be used in a selective and adaptive way. This offers the following advantages:

- Information that is not needed at the moment can be suppressed, and the display contents reduced to the essentials (i.e., what is actually required for the current situation);

- Since it can be adjusted to the ambient lighting conditions, the electronic chart can be located so that it can be continually viewed from the steering position. Adverse effects on night vision caused by the night lighting of the chart table are removed;
- Chart information is automatically changed as the vessel transits along the planned route. The ‘current chart’ is always available and can be immediately shown at a desired scale;
- Colour setting of the electronic chart display accentuates dangerous areas and clearly delineates safe waters.

Another key aspect is situational awareness. For Watch Officers, situational awareness relates to the ability to maintain a clear picture of the current situation coupled with a border overview of anticipated events. It involves the gathering of many types of information (visual, printed text, and geo-spatial) from a variety of sources. It also relates to properly interpreting this information and the ability to determine what is crucial for the task-at-hand. With an electronic chart system, this decision support task is performed automatically. When properly used, it has been found that an electronic chart system actually enables the Watch Officer to spend more time looking out the window thus keeping more alert to the ‘big picture’.

➢ **Radar Overlay**

The safety potential can be increased when an electronic chart system includes radar integration. This technique unites two instruments that have been developed for two separate – but related, navigation tasks:

- Electronic chart for grounding-avoidance;
- Radar for collision-avoidance.

In this manner, a Mariner views virtually all the important navigational information on a single display. The accuracy of the position can be also assessed through the level of agreement of the radar and electronic chart images. This so-called ‘map matching’ technique can be used to confirm that the radar position conforms with the position of charted information as determined by the positioning sensor.

➢ **Automatic Route Monitoring**

Improvements in safety are not limited to a better visual perception of the current navigational situation. An electronic chart also enables the introduction of several new types of navigation information:

- A planned route can be checked for the minimum water depth and the minimum distance from dangerous objects;
- The anti-grounding function monitors the sea area being transited, and can prevent grounding by providing an indication or alarm at the appropriate time;
- The look-ahead function monitors the sea area ahead of the ship for obstacles such as buoys and isolated dangers;
- If a radar image is integrated into the electronic chart display, the radar/ARPA can be set to automatically alarm if other vessels in the vicinity are on a potentially dangerous course;
- Exceeding the maximum cross-track deviation from the planned route can be unambiguously displayed.

- **Automatic Track Control**

If the electronic chart is integrated with the automatic track control system, the ship can automatically transit along the pre-planned route. The straight legs of the route will be followed along the optimal course. Course changes at pre-planned and designated waypoints will be automatically executed along a planned turning radius. The ship will move along the route that had been precisely laid out with the proper safety margins during the planning stage. All this can be continually monitored and confirmed through direct observation and automatic alarms.

- **Reduction of Human Error**

Alarms, indications and other forms of warnings are set off during automatic monitoring based on pre-established parameters set by the Watch Office. They can also be caused by sensor failures or when planning a route through dangerous waters. These functions pertain to the effective operation of the ship and give the Mariner time for tasks requiring his qualified assessment. This includes surveillance of the surrounding sea area, traffic situation and ship maneuvers. One example of the various indications, warnings, and alarms that would have been provided if an ECDIS had been installed onboard is the grounding of Exxon Valdez in Prince William Sound, Alaska on 24 March 1989. There could have been up to five warnings/alarms given that the vessel was in danger of running aground on Blight Reef. (1) Leaving the outbound lane, (2) crossing the separation zone of a TSS, (3) crossing into the inbound lane, (4) leaving a TSS, and (5) crossing a safety depth contour and individual spot sounding.

- **Help in Special Maneuvers**

Additional functions can also come into play during emergency situations such as 'man-overboard' maneuvers. For instance, the position of the event can be marked on the electronic chart with a single key operation and reached precisely again through a graphically pre-planned turn-around maneuver. Should it be necessary, search maneuvers can be then automatically carried along a prescribed pattern calculated in advance using the electronic chart.

A planned anchoring spot can be precisely approached, and the stopping of the ship easily recognized. Likewise, rapid determination of whether the anchor is holding or dragging can be automatically monitored. Also the situation during maneuvering and docking can be very accurately judged through the true-to-scale display of own ship on the electronic chart display. For instance, when using a bow-thruster while maneuvering alongside a pier, the effects can be immediately assessed.

- **Up-to-date Information**

The time-consuming task of voyage planning using paper charts has been replaced by more effective methods. Gone is the laborious handling of the large stacks of paper charts, and also the exhausting task of measuring or entering of geographic coordinates required for route planning. However, the main saving is through replacement of the time-consuming manual corrections of the charts and nautical publications by the regular updating of the database, either with help of data carriers or remotely controlled and automatic. The safety advantages of such on-line data services are significant since the chart information is always up to date. Another advantage is that the computer-supported integration of the actual changes to the database avoids the errors that could be made when updating is performed manually.

CH. 4: CORRECT AND INCORRECT USE

4.1: ECDIS within the Prevailing Navigation Situation

" … ECDIS is only a navigational tool which helps to perform the navigational functions and that its limitations, including those of its sensors, make over-reliance on it dangerous."

"Emphasis must be placed on the need to keep a proper look-out and to perform periodical checking, especially of the ship's position, by ECDIS-independent methods. With or without the use of ECDIS, all navigational activities have to comply with the basic principles and operational guidance for officers in charge of a navigational watch (STCW; SOLAS)."

Watchkeeping Principles
Watches shall be carried out based on the following bridge and engine-room resource management principles:

- proper arrangement for watchkeeping personnel shall be ensured in accordance with the situations;
- any limitation in qualifications or fitness of individuals shall be taken into account when deploying watchkeeping personnel;
- understanding of watchkeeping personnel regarding their individual roles, responsibility and team roles shall be established;
- the master, chief engineer officer and officer in charge of watch duties shall maintain a proper watch, making the most effective use of the resources available, such as information, installations/equipment and other personnel;
- watchkeeping personnel shall understand functions and operation of installations/equipment, and be familiar with handling them;
- watchkeeping personnel shall understand information and how to respond to information from each station/installation/equipment;
- information from the stations/installations/equipment shall be appropriately shared by all the watchkeeping personnel;
- watchkeeping personnel shall maintain an exchange of appropriate communication in any situation; and
- watchkeeping personnel shall notify the master/chief engineer officer/officer in charge of watch duties without any hesitation when in any doubt as to what action to take in the interest of safety.

Operational Guidance
The following describes the principles to be observed in keeping a navigational watch as extracted from STCW Code including 2010 Manila Amendments:

- the officer in charge of the navigational watch is the master's representative and is primarily responsible at all times for the safe navigation of the ship and for complying with the International Regulation for Preventing Collisions at Sea, 1972, as amended;
- maintenance of an efficient lookout; the separate duties of a lookout and a helmsman;
- determining that the composition of the navigational watch is adequate;
- watch arrangement;

- taking over the navigational watch and performing the navigational watch;
- periodic checks of navigational equipments;
- the use of engines and sound signalling apparatus;
- conditions when to call/notify the master;
- protection of marine environment; and
- watchkeeping under different conditions and in different areas:
    - clear weather
    - restricted visibility
    - in hours of darkness
    - coastal and congested waters
    - with pilot on board
    - and/or when at anchor

4.2: Ways to avoid over-reliance on ECDIS

Risk of Over Reliance

Basic navigation has always dictated that at least two systems are required to cross check a positional fix. ECDIS has to allow this practice to continue by facilitating the necessary traditional methods of navigation. This includes the ability to establish Parallel Indexing for radar use, Clearing Bearings and Heading Marks for visual navigation. An onboard procedure needs to be established that ensures the primary fixing method, which appears on the ECDIS, is checked using traditional methods. This is a reverse of past training when it was stated that Electronic Navigation Systems are only aids and should be used to verify visual or radar position fixes.

The accuracy that is available from modem navigation systems is a major benefit to the navigator. A continuous display of the vessel's position is difficult to achieve with visual or radar fixes, especially to the same accuracy available from modern navigation systems. It is logical to use the most accurate and beneficial navigation system available; on ECDIS, this is the electronic navigation system. The vulnerability of these systems is their reliance on technology and not experience or good seamanship. ***Hence, emphasis must be placed on the need to keep a proper lookout and to perform periodical checking, especially of the ship's position, by ECDIS-independent methods. With or without ECDIS, all navigational tasks must comply with the basic principles and operational guidance for officers in-charge of a navigational watch (SOLAS; STCW).*** The prudent mariner will continue to monitor the performance of the ECDIS with visual or radar information.

ECDIS user should be aware of errors that are not inherent in the ECDIS system or its connected units but results from misunderstanding, inexperience or careless observation by the operator (human error).

Hence, to interpret the data presented, user must have a complete understanding of the system including its limitations. Aside from the other factor like complacency (the user no longer need to plot position as the system does it for him), over-reliance on information displayed, erroneous judgment due to a wide variety of reasons can further jeopardise the navigational safety of the vessel.

Some of the most typical errors on interpretation result from:

i. **Ignoring over-scale of the display**
User must be aware of that the scale of the SNC should be made only within the reasonable limits. All ENCs are originally complied on a certain scale. If the chart information is displayed in larger than that in which ENC data i.e. from which the SENC has created then the quality of the displayed data cannot be trusted no longer.

ii. **Unaware of isolated underwater danger setting**
User must be aware that ECDIS uses a conditional symbology procedure to determine when to display an underwater danger. In areas that lie within the safe waters defined by the safety contour the symbol will be displayed if the underwater obstruction is shallower than the defined contour.

iii. **'95% probability' of the accuracy**
Uncritical acceptance of own ships position by ignoring the 95% probability of the accuracy:
The vessel's position is denoted by double circle on the electronic chart. This position has the probability of 95% accurate. Example, if the accuracy of the position fixing system is 100m, that means there is 95% chance of the vessel to be in 100m circle, where as there are still 5% chance that vessel position may lie outside the 100m accuracy circle.

iv. **Automatic Track Control**
Ignoring the fact that, in automatic control mode, the observer position is controlled, not the real ship itself:
User must understand that in auto track control mode, it is the GPS (or position fixing sensor) position (observed position) is checked for controlling, hence if GPS position is out, what will be displayed on chart and ECDIS will correct cross track difference which may lead to grounding.

v. **Difference between true north and gyro north (radar)**
User must understand what causes the gyro error, like speed and latitude corrections. Whereas vessel is navigating on the true north, hence gyro must be adjusted for the corresponding speed latitude input; and frequently gyro error must be checked.

vi. **Confusion of display mode, scale, reference system**
Different display modes like north up and course up orientation may lead to wrong interpretation and inaccuracy of observation of the data which may lead to wrong action taken by the observer. Optimum scale of the chart must be used for the area where vessel is navigating because as per IMO Performance Standard, ECDIS should give an alarm or indication for the largest scale chart for that area for any underlying alerts as selected by the user. Also, if user chart display is on different scale ECDIS should again warn the user by an alarm or indication that the chart displayed is under-scale or over-scale.

vii. Confusion of different types of vector stabilization

Radar/ARPA uses 'over water' reference vector display for collision avoidance while ECDIS uses 'over ground' reference display to monitor vessel's position monitoring over ground. Hence, there can be a conflict when user is comparing both the vectors and related results.

viii. Operational Anomalies within ECDIS

An ECDIS anomaly is an expected or unintended behaviour of an ECDIS which may affect the use of the equipment or navigational decisions by the user. Examples include but are not limited to:

i. A failure to display a navigational feature correctly;
ii. A failure to alarm correctly;
iii. A failure to manage number of alarms correctly.

ix. Danger of Over-Reliance on ECDIS

ECDIS is a tool that helps to navigate a vessel safely and efficiently. It is not a "cure-all" for problems encountered while navigating a ship. Bridge team members are reminded against over-reliance on the ECDIS information provided. Discussion, and if required training, on errors should be carried out as part of BTM meetings before commencement of passage and any specific items should be attended to as part of evaluation and improvement of passage plan. Considerations should be given to at least the following possibilities:

a. Poor GPS performance;
b. DGPS used/not used
c. Manipulated GPS signal (system external interference);
d. ECDIS malfunction;
e. Installation setup;
f. ENC compilation errors (e.g. datum);
g. Chart errors (omissions, out-dated);
h. Error in interpretation;
i. Survey errors;
j. Display errors;
k. Human error (including user input errors)

Hence, it is really important to check that the:

a. Reference system is common
b. Charts in used are updated
c. Chart scale in use is appropriate
d. Right sensor input – by verify accuracy and sensor is chosen accordingly
e. Safety values are entered appropriately. Understand their meaning and importance
f. Display category is appropriate (what is required to be displayed, user's choice)
g. Vessel's position is cross checked by other means

4.3: Proficiency in the Use of ECDIS Includes Assessing the Integrity of the System and all Data at all Times.

With increasing automation and reliability of ship's navigation systems, it is easy to place undue reliance upon them. In particular, positioning, even when just GPS is used, is rarely noticeably inaccurate and seemingly always available. An individual may not experience or notice any problems, even over extended periods and therefore may become complacent. However, real problems do occur and every year a number of these lead to serious incidents for unwary navigators.

A good OOW is continually seeking either to confirm or deny the integrity of the navigation system and solution. Importantly, checking of positional integrity also help keep the OOW properly aware of the current navigational situation. Then, if the electronic equipment failure occurs, either totally or by giving false readings, the navigator will recognize early, and more safely manage, the abnormal circumstance.

It is therefore important that the immediate planned route and its potential dangers always remain fully in mind so that quick decisions can be made if the system fails. Of course, these decisions require much more information than is directly obtainable from ECDIS.

ECDIS Failure

Similarly to other electronic navigational equipment, ECDIS can fail, either outright or in a way that can give misleading information. It could be argued that an outright fail is preferable because of its self-evidence, forcing the bridge team to take action and to navigate with great caution in the meantime. Unfortunately, 'softer' problems may not attract the rapid attention of the navigator, even though misleading information could be displayed. In addition, since ECDIS relies on data from other navigation sensors, it can also display misleading information generated by these. As previously noted, positioning errors are always a possibility and so knowledge and guidance about this issue are essential. Never rely on a single source of data. Always apply consistency checks with other sources. By keeping a full awareness of the current situation, anomalies should be readily identified. It is highly important that the navigator maintains a good visual lookout, as this particularly helps to bring together all displayed information into a coherent mind picture, as well as the eyes acting as an important sensor of information.

When an ECDIS is switched on, it goes through a series of checks and any detected anomalies will result in an error message, generally as an indication on the screen, rather than as a navigational alert. Any such messages should be noted and addressed appropriately; guidance should be available within the user manual. During use, an ECDIS will attempt to self-monitor problems, which if detected will result in an indication or a navigation alarm, depending on its severity. However, the equipment is unlikely to be able to detect all faults that could give rise to the display incorrect navigational information, emphasizing the need for continued vigilance on behalf of the OOW.

If there is a perceived problem with the primary ECDIS it is probably best in most circumstances to take steps immediately to initiate working with the back-up facility.

Assistance on the bridge should be immediately summoned and an entry made in the ship's log. IMO's requirements for back-up arrangement are given in MSC 82/24/Add.2 Annex 24.

Many faults can often be cleared simply by restarting the ECDIS. For instance, blank or corrupted displays, ultra-slow response to commands, or an inability to remove system error messages (rather than navigation alerts) can feasibly all be corrected by switching off the unit, and after a short wait, switching it back on. During this shutdown and restart sequence the ship should be navigated on the back-up system and the OOW should not be directly involved with the restart procedures. If it is possible, the standard menu command to shut down the ECDIS should be utilized, as this will reduce the possibility of re-start problems.
The user manual may give guidance on the preferred procedure when the normal menu for shut down is unavailable or fails to work. For instance, on some systems it is possible to effect shut down by simultaneously pressing the Control, Alt and Delete buttons on the keyboard and following the on-screen messages. As a final resort, it may be necessary to use the main switch on the equipment or in the main feed to it. Re-Starting after a non-standard shutdown can take rather longer than normal, emphasizing the need to first concentrate on transferring navigation to the back-up system. If the original problem persists, then the back-up must continue to be used until the unit can be repaired. However, it would be appropriate to attempt the re-start procedure at least a second time.

CH.5: WORK STATION START, STOP AND LAYOUT

5.1: Switching ECDIS ON and OFF

When an ECDIS is first switched on, as with a personal computer, it will take some time for the equipment to load and configure the software. And at some stage in the process it is possible, but undesirable, that a password will have to be entered. The equipment should normally be left operational at sea. If, for any reason, it needs to be turned off, it is normally performed by selecting the appropriate menu functions. This enables an orderly shut-down to take place. Only an emergency, perhaps if the equipment is obviously overheating, should it be shut down form the equipment power switch. This particular method of shut-down is unlikely to damage the ECDIS but it may take considerably longer to restart at the next switch-on. It may also require certain options being selected by the user during start-up. In both menu-driven and emergency shutdown cases, when switched on again, the equipment will return to the display settings in operation at shut-down.

Some aspects of the operating system, such as Microsoft Windows, may become visible during the start-up process. If error or warning messages are given by the operating system they should be noted and a manufacturer-authorized technician should be informed.

In normal circumstances, an ECDIS being used for navigation should not be switched off during the voyage. In some instances, when left on for a long length of time the ECDIS operation may become increasingly slower, by a process known as ***memory leak***, which can occur with poorly designed software. If this happens, the equipment should be shut down, normally by using the appropriate menu command, and then restarted.

When ECDIS is first switched on, its time and date should be checked using the appropriate menu command. Unlike PCs connected to the Internet, these will not be corrected automatically, unless the ship's system includes a master clock on the navigation network. The clock should be set appropriately as UTC, local time or to the time zone specified in the Bridge Instructions. The date should be checked as this is used in a number of data recording functions.

5.2: Interpret the ECDIS start windows for sensors requested, sensors found, and selected chart data initializing

System Configuration (Example FURUNO: FEA-2807/2107/2107-BB)
The ECDIS EC1000C Workstation, comprised of the components shown in the illustration below, displays electronic sea charts and operates as the user interface for the system.
The ECDIS processor is connected to various sensors, and performs navigation calculations and route monitoring.
Connections to interfaces are typically made with a LAN (Local Area Network) Adapter.
The ECDIS processor can be used for both route planning and route monitoring. If required, there can be additional identical ECDIS EC1000C Workstation(s) connected to the same LAN to share the tasks of the ECDIS. If the system incorporates more than one ECDIS EC1000C Workstation, one or more workstation(s) can be used as a user interface (with "full" usage rights) and one or more workstation(s) may be used as planning stations (usage rights as "planning").
If the system has two workstations connected together as multiple workstations, the system keeps data on the workstations harmonized and also tracks selections and settings made on any workstation.
Typically there can be the following kinds of configurations of workstations:

- Mode as **Single**, only one workstation is used in the system.
- Mode as **Multiple**, two workstations are used in the system where usage rights and sensor source of workstations can be changed by the operator.

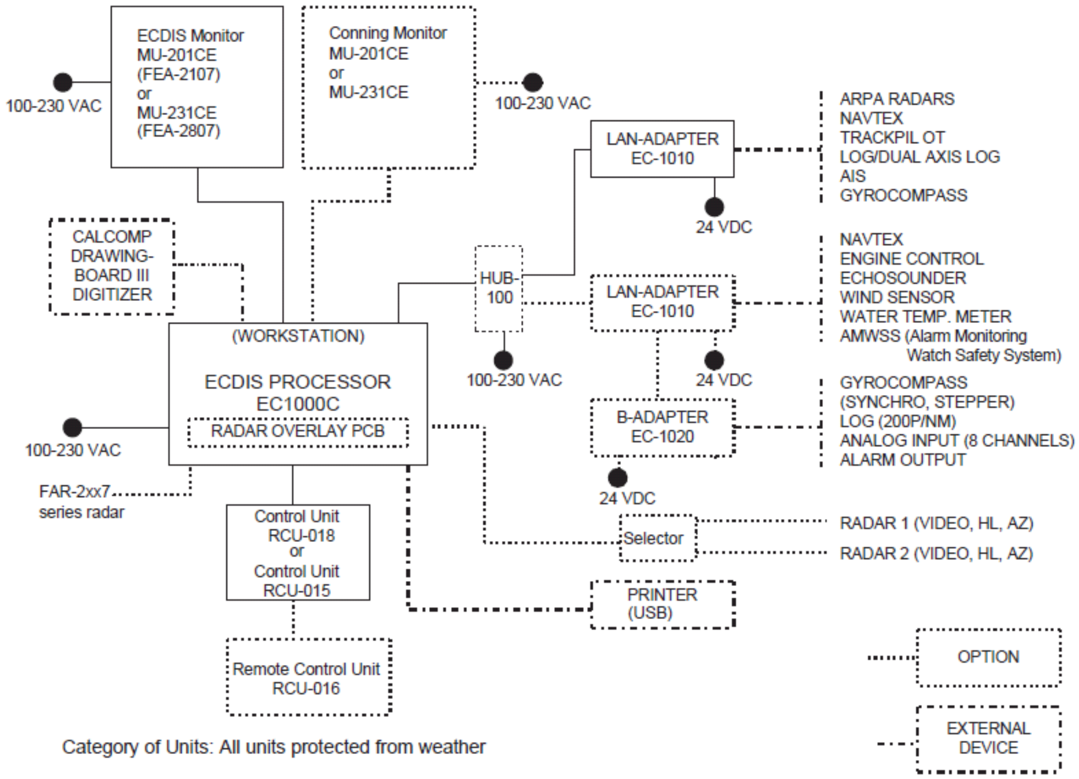


Fig. 5.1: Example of a Single Workstation with connection to navigation sensors

In the multiple workstation configuration, there can be four workstations connected together by a Local Area Network (LAN). In this configuration, one workstation is used as the "sensor source" for navigation sensors and the other workstation(s) are used as the sensor source workstation to communicate with sensors, receiving and transmitting data from/to workstation via the LAN. In the multiple workstation configuration (two fully redundant navigation workstations), where navigation sensors are connected to two or more workstations, the sensor source may be changed and still receive and transmit information from/to the system and to/from navigation sensors.

ECDIS Activator Key (Dongle or Protection Key)

Compatibility with CM-93 format depends on commercial agreements. Some versions of this ECDIS are compatible and others are not. The compatibility is controlled by the security device called a dongle. From CM-93 format the ECDIS generates SENC which is used for actual operations of the ECDIS. The difference between S57ed3 ENC charts and CM-93 charts is that the CM-93 charts are from a private source and they cannot be used as a substitute for paper charts under any condition. To emphasize this point these charts are called "Non-ENC" charts in this manual.

HASP- Hardware against Software Piracy

The ECDIS software boots up (loads) with:

- A small indicator window against the desktop background, then
- A full screen panel indication of initialization, then

- The ECDIS basic display with alarm indicators (if any) requiring acknowledgement.

5.3: Examine Alarms (if any) and Determine Initial Conditions of ECDIS Readiness for Navigation

The ECDIS initialization screen indicates on-line tests:

- For date/time, position, heading, and speed log,
- Displays “Received” when these inputs match expected protocols (“Received” status is not a check on data accuracy),
- Displays “Aborted” when these inputs are missing or corrupt,
- Boot-up without inputs will continue, with alarms on ECDIS display,
- ENC data will be loaded from the chart files as licensed.

ECDIS Alerts

Alerts generated by ECDIS can be divided into three categories:

- **Alert -** only the most urgent alerts which needs your attention. The alert initially flashes in red and an audio alarm sounds until acknowledged. After acknowledgement, the alert is shown in plain text and the audio alarm stops.
- **Warning -** the most of alerts are in this category. In addition to text on flashing yellow background, a short beep generated by ECDIS, if not acknowledged in 60 seconds, then continuous beep until acknowledged (or short beep repeated every 60 seconds).
- **Caution -** few alerts only having only text on flashing yellow background without audible sound.

Indications for Doubtful Integrity

There are few cautions that indicate which sources are considered doubtful integrity. These kinds of cautions are "404 Gyro data unreliable", "405 Log data unreliable", "407 Position discrepancy", and “413SOG/COG data unreliable”.

When any of above caution is on, doubtful value itself is yellow. In addition to this a short beep is generated and flashing yellow indication until acknowledged.

Following values themselves are turned yellow in upper right corner when there is doubtful integrity:

- LAT & LON values of own ship position
- Gyro value
- Speed value
- SOG/COG values

Following values in Sensor page turn yellow when there is doubtful integrity:

- Position sensors (position discrepancy)
- Position sensors (filter exclude)
- Gyro sensor
- Log sensor

- SOG/COG sensors (dual axis log and position sensors)

Ch. 6: VESSEL POSITION

6.1: User Interface Method

User Interface

The *user interface* or also called *as human-machine interface* ('HMI') is defined as the areas that are not displaying the electronic chart, either raster chart or vector chart.

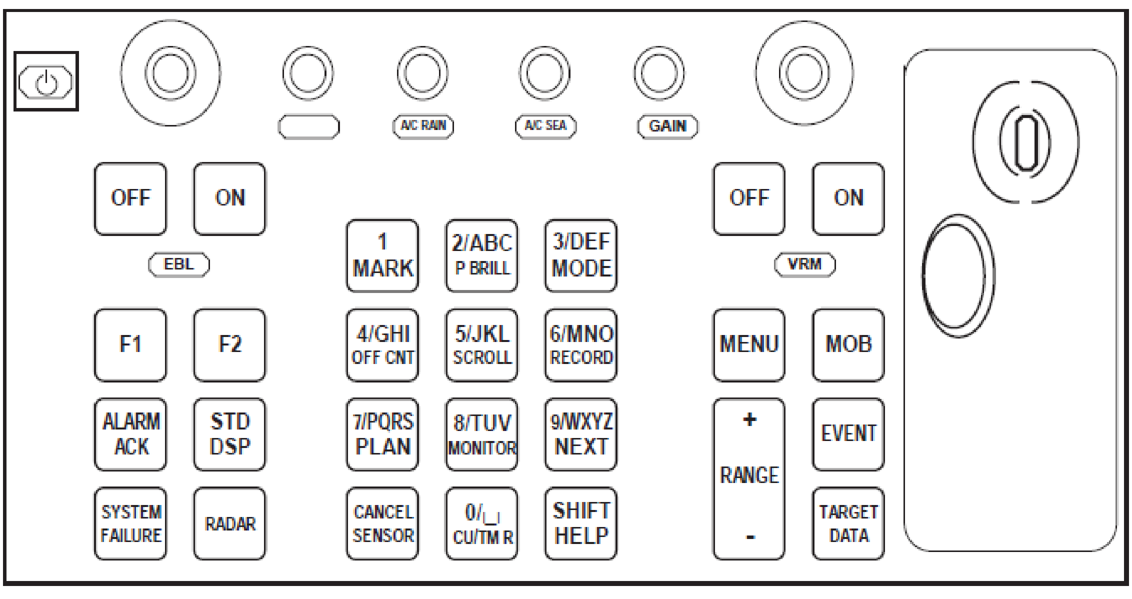
The user interface contains information about settings, parameters and selections used by the ECDIS and combines functional levels ('Which function should be used?') with operational levels ('How will the function be executed?'). The nature of the information displayed can be either static (such as name of a certain window, fields in chart legend, units, etc.) or dynamic (such as position of your ship, time, operator selections, etc.).

Example of control unit (RCU-018)

The Control Unit RCU-018 consists of a keyboard, the trackball, a scroll wheel and mouse buttons. The trackball functions like a mouse; the operator rolls the trackball and operates the left and right mouse buttons to access functions.

Key Description

POWER	Turns the system on/off. (This control does not switch the display on/off.)
VRM rotary encoder	Adjusts active VRM.

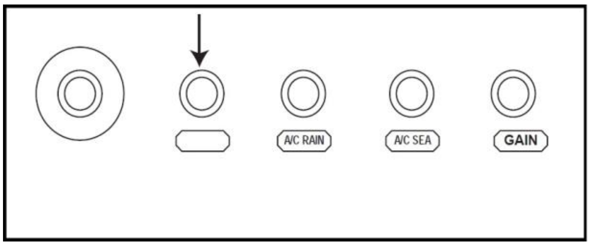


Layout of the control unit RCU-018

VRM ON	Activates and displays VRM 1 if none is displayed or VRM2 is active. Activates and displays VRM 2 if VRM1 is active.
VRM OFF	Inactivates and erases VRM 1 if both VRMs are displayed. Inactivates and erases VRM 2 if VRM1 is active.
EBL	rotary encoder Adjusts active EBL.
EBL ON	Activates and displays EBL1 if none is displayed or EBL 2 is active. Activates and displays EBL 2 if EBL1 is active.
EBL OFF	Inactivates and erases EBL1 if both EBLs are displayed. Inactivates and erases EBL 2 if EBL1 is active.
F1	Activates operator-defined function or menu.
F2	Activates operator-defined function or menu.
ALARM ACK	Alert acknowledgement for alerts generated by chart, navigation or steering calculation.
SYSTEM FAILURE	The red lamp behind the key lights and the buzzer sounds when system failure is found. Hit the ALERT ACK key to silence the buzzer. The key remains lit until the reason for the problem is removed. System failure: control unit cannot communicate with EC-1000C. (EC-1000C is inoperative.)
RADAR	Displays Radar Overlay dialog box, which provides functions for adjustment of the radar picture.
STD DSP	Activates standard display presentation on the ECDIS. Restore monitor brilliance to calibrated state.
1/MARK	Displays the Nav. Marks dialog box, which mainly provides for activation/deactivation of various markers.
2/ABC/P BRILL	Adjusts control unit dimmer.
3/DEF/MODE	Selects presentation mode: North-up TM, Route-up RM, Course-up RM, North-up RM, Course-up TM.
4/GHI/OFF CNT	Off centers your ship's position to cursor location on the ECDIS display. Press again to return your ship's position to screen center.
5/JKL/SCROLL	Enables scrolling on ARCS charts, with the trackball active.
6/MNO/RECORD	Opens Voyage Record sub menu.
7/PRQS/PLAN	Opens Plan Route dialog box.
8/TUV/MONITOR	Opens Monitor Route dialog box.
9/WXYZ/NEXT	Opens "Next" page in multi-page dialog box.
CANCEL/SENSOR	Opens Sensors dialog box; closes open dialog box or window.
0/space CU/TM R	Returns your ship marker to screen center in TM and CU modes; inserts a space.
SHIFT/HELP SHIFT	Shifts between lower case and upper case alphabets.
HELP	Activates info/help. (Mouse must not be over input field.)
MENU	Displays the Main menu.
+ RANGE	Adjusts charts scale.
MOB	Inscribes MOB mark on the screen.
EVENT	Records textual information fixed to your ship's position.
TARGET DATA	Shows target data for selected Tracked Target; provides data for selected chart area.
GAIN	Adjusts radar gain on the radar overlay.

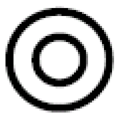
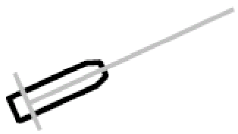
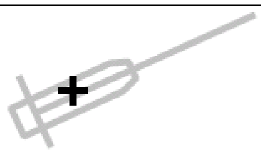
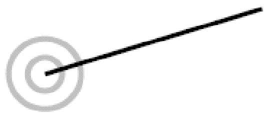
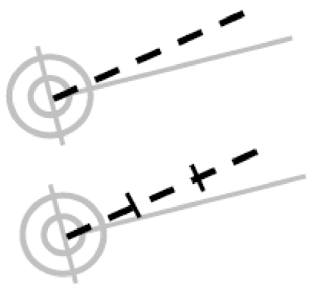
A/C RAIN Reduces rain clutter on the radar overlay.
A/C SEA Reduces sea clutter on the radar overlay.

Adjust backlight brilliance of ECDIS display(s). Color calibrated backlight brilliance can be set using "Standard Display" button or selecting desired "Palette" in the Chart page of the Display window.



6.2: Display of Vessel's Position

NOTE:
(The same symbology used in Chapter 29: AIS - Symbology)

Topic	Symbol	Description
Own ship Symbol		Double circle, located at own ship's reference position. Use of this symbol is optional, if own ship position is shown by the combination of Heading Line and Beam Line.
Own Ship True scale outline		True scale outline located relative to own ship's reference position, oriented along own ship's heading. Used on small ranges/large scales.
Own Ship Radar Antenna Position		Cross, located on a true scale outline of the ship at the physical location of the radar antenna that is the current source of displayed radar video.
Own Ship Heading line		Solid line thinner than the speed vector line style, drawn to the bearing ring or of fixed length, if the bearing ring is not displayed. Origin is at own ship's reference point.
Own Ship Beam line		Solid line of fixed length; optionally length variable by operator. Midpoint at own ship's reference point.
Own Ship Speed Vector		Dashed line - short dashes with spaces approximately twice the line width of heading line. Time increments between the origin and endpoint may optionally be marked along the vector using short intersecting lines. To indicate Water/Ground stabilization optionally one arrowhead for water stabilization and two arrowheads for ground stabilization may be added.

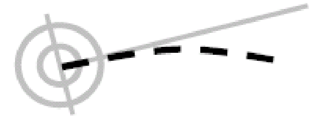
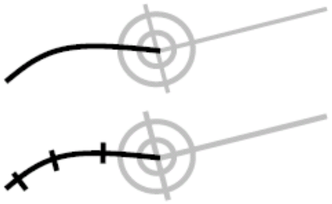
Own Ship Path prediction		A curved vector may be provided as a path predictor.
Own Ship Past track		Thick line for primary source. Thin line for secondary source. Optional time marks are allowed.

Table 6.1: Own ship symbology according to IMO SN 243 [IMO Circular NavSymbols].

6.3: Position Information in the Display Panel

Display Interpretation

The conning display shows collected data from different sensors, and the data below is available for display. However, this depends on which sensors are installed and connected on board the ship.
Typically information which is displayed on the conning display are received from following sensors:

- Position sensors
- Wind sensor
- Gyro
- Rate of turn gyro
- Log
- Dual-axis log
- Rudder
- Propellers
- Thrusters

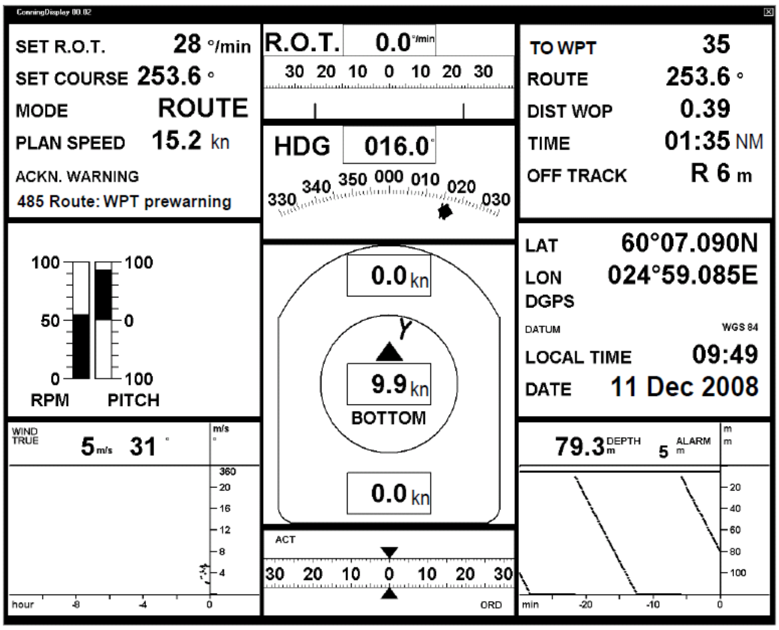


Fig. 6.2: Typical layout of conning display in navigate mode

The display is composed of the following windows:

- ROT window
- Heading window
- Speed window
- Rudder window
- Position window
- Drift and radius window
- Autopilot window
- Route window
- Weather and wind window
- Depth window
- Combined wind, depth and destination window (for DNV specification)
- Fuel consumption window
- Thruster window
- Propellers window
- Azimuth propulsion window
- Speed pilot window
- Message window
- Main engine start air pressure window
- Alert messages window
- Propulsion and thruster window (for DNV specification)

6.4: Position fixes defined by Line of Position (LOP)

For coastal legs, the taking of visual bearings remains an important aid to establishing positional integrity. Conventional visual determination of position relies on taking and plotting three lines of position (LOPs); with the ship's position being assumed to lie within the resultant 'cocked hat' (triangle). Facilities to enable LOPs to be easily plotted on ECDIS are available on many systems, and it is now an IMO requirement for all new equipment. However, it can be argued that a better approach in many circumstances is to take a frequent single LOP, possibly, but not necessarily of the same charted object, maybe at ten-minute intervals for a typical coastal leg, and rapidly transfer each on to ECDIS, using the LOP or EBL facility, whichever is most convenient. As far as possible, consecutive sightings should be at bearing 'intervals' which are approximately 'orthogonal', that is 90º or 270º to the previous sighting.

It is customary that the LOP is plotted from the charted object towards the ship's expected position and the equipment should provide an easy way of facilitating this, which typically involves selecting the identified object on the chart with the cursor and applying the appropriate menu selection – or vice versa. If the LOP does not pass close to the electronically derived position of the ship, then it is first necessary to confirm that the sighting itself was correct. For instance, was the correct object sighted or was a human error made in transferring the bearing to the ECDIS? If the sighting is confirmed, an electronic position fix error should be suspected, prompting a comparison of the primary position fix system with the secondary, followed by other methods to assist with the diagnosis of the problem.

Estimated Position

If automatic positioning totally fails or has become too inaccurate for safe navigation, then it will be necessary to take regular manual fixes and rely on estimating position between each manual fix. On an ECDIS conforming to the latest IMO performance standards, set positions can be used as the origin for subsequent estimates of position. The set position can be provided by the LOP facility or by a manually input position.

A position determined using comprehensive data sources, or a series of fixes, is commonly known as the *Estimated Position* (EP). Simple estimates of position taking into account only speed and course are often known as *Dead Reckoning* (DR), although there is a blurring in the usage of the terms. EP techniques can result in a reasonably good continual estimate of position over a period between fixes extending even to several days, although the absolute accuracy decreases steadily with time.

The use of EP as a primary position estimate should only be used in emergencies, where it can be invaluable. To remain practiced in its use and to gain a better knowledge of its likely accuracy in different conditions, it is useful to occasionally use the ECDIS to perform an extended EP (using the secondary track facility or the back-up ECDIS) regularly comparing its performance with GNSS derived position.

Recording Positions

The operator may manually save positions to the voyage log in various ways. These are:

- Direct sensor position (GPS, Loran, etc.)
- Positions calculated by the system (in example below such are Kalman filter and Dead reckoning)
- User observations. (Visual, astronomical and MFDF. MFDF is Medium Frequency Direction Finder.)

CH. 7: POSITION SOURCE

7.1: Concept of GPS (Global Positioning System)

GNSS (Global Navigation Satellite System) is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world. Two GNSS systems are currently in operation: the United States' Global Positioning System (GPS) and the Russian Federation's Global Orbiting Navigation Satellite System (GLONASS). A third, Europe's Galileo, is slated to reach full operational capacity last 2008. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations.

Development of GPS

The US Global Positioning System was first developed in the 1970s and 1980s, mainly as a military system. A fully operational constellation of 24 satellites was available from 1993. It was originally called NAVSTAR, which some people assume stands for Navigation System with Timing and Ranging, although it was originally coined as *'simply a nice sounding name' (as related in 1994 by Bradford Parkinson, considered to be the Father of GPS)*. The concept of GPS was first developed in the late 1960's but the first satellite was launched in the year 1978 and the last one in the series of 24 earth orbiting satellite was placed into orbit in June of 1993. And it became fully operational in 1994. These 24 satellites are circulating earth above a distance of 20, 200 km in 6 orbits (4 in each) with an inclination of 55 degrees to the equatorial plane. All these satellites are controlled by the GPS Master Control Station (MCS) situated in Colorado. There are four real time tracker antennas in the ground and five passive- tracking stations to monitor all kinds of GPS activities. GPS receivers use triangulation technique in which the area is divided into a series of triangles for accurate 3D measurements of distances.

A previous US satellite navigation system was called "Transit" and, from 1967, civilian use was permitted and became fitted on a number of merchant vessels. Transit was a UHF Doppler based system with only a few in-service low-orbit satellites. For this reason it only gave a fix every hour or so, with a navigation accuracy of no better than 200 meters.

Advances in atomic clock technology enabled development of the NAVSTAR-GPS concept, together with the principle of using a modulation based on pseudo-random (digital) noise (PRN). It is a space-based satellite navigation system consisting of a constellation of satellites and a network of ground stations that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to four or more GPS satellites. It is maintained by the United States government and is freely accessible by anyone with a GPS receiver.

GPS Infrastructure

- **Space Segment** consists of the GPS satellites. These satellites send radio signals from space.
- **Control Segment** consists of a system of tracking stations located around the world.
- **User Segment** consists of the GPS receivers and the user community. GPS receivers convert satellite signals into position, velocity, and time estimates. Four satellites are required to compute the four dimensions of X, Y, Z (position) and Time. GPS receivers are used for navigation, positioning, time dissemination, and other research.

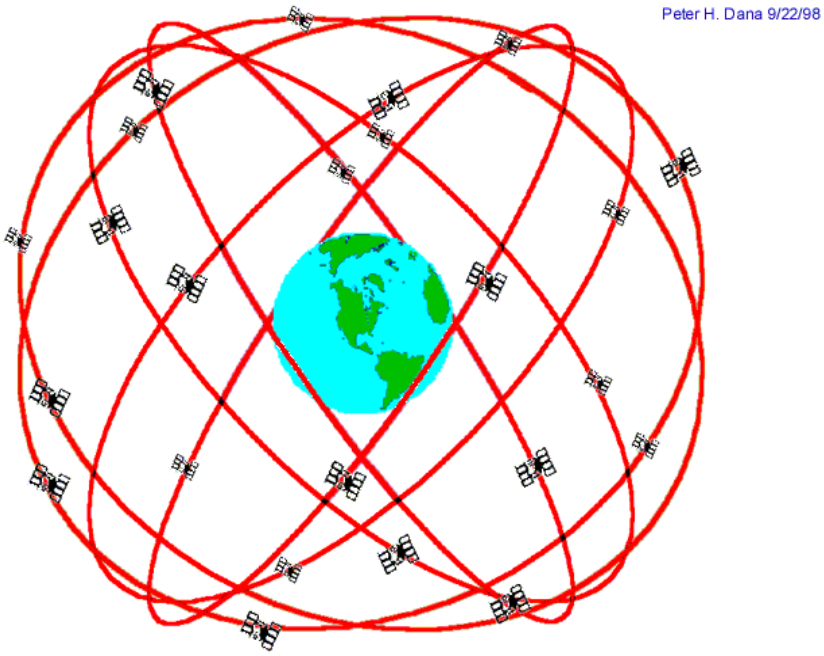


Fig. 7.2: GPS Nominal Satellite Constellation with 24 Satellites in 6 orbital planes

Satellite Constellation

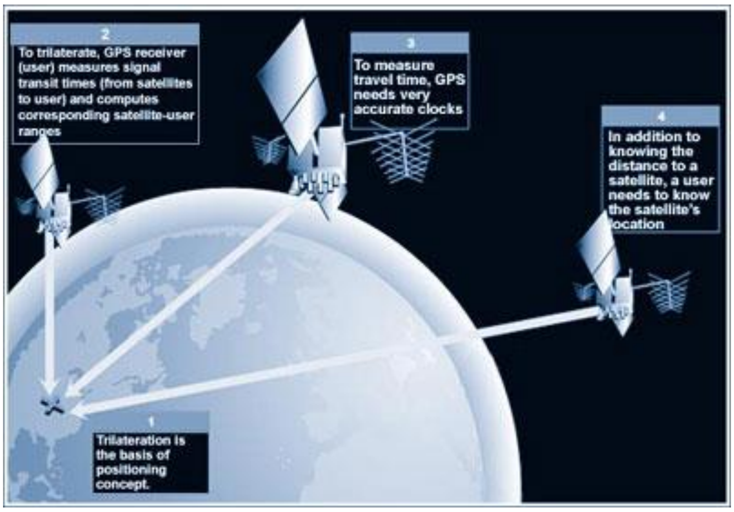
Although only four satellites are needed to provide a three-dimensional position fix, many more are needed to create a globally useful constellation. The fundamental laws of physics make it impossible to have a set of satellite that remain stationary with respect to the Earth but also give a global positioning capability. For this reason global navigation satellites have orbits that move relative to the Earth. The orbits are chosen to ensure a predictable coverage giving good PDOP's at any position and time.

Typically the orbits are in some way synchronous to the Earth's rotation, appearing in the same place in the sky at simply defined intervals measured in sidereal days.

Satellites are placed at equal intervals on a number of orbital planes. For instance, both GPS and GLONASS nominally use eight satellites in three orbital planes. The planes are chosen to give good total Earth coverage; typically six satellites are viewable at any time from most areas on the Earth. Physics prevents synchronous orbits in planes approaching polar orbits and therefore Polar Regions are somewhat compromised. In this respect, GLONASS gives better polar performance than GPS, because of its particularly chosen orbits.

GPS - How It Works

Satellite Navigation is based on a global network of satellites that transmit radio signals in medium earth orbit. Users of Satellite Navigation are most familiar with the 24 Global Positioning System (GPS) satellites*. The United States, who developed and operates GPS, and Russia, who developed a similar system known as GLONASS, have offered free use of their respective systems to the international community. The International Civil Aviation Organization (ICAO), as well as other international user groups, have accepted GPS and GLONASS as the core for an international civil satellite navigation capability known as the Global Navigation Satellite System (GNSS).



The basic GPS service provides users with approximately 7.8 meter accuracy, 95% of the time, anywhere on or near the surface of the earth. To accomplish this, each of the 24 satellites emits signals to receivers that determine their location by computing the difference between the time that a signal is sent and the time it is received. GPS satellites carry atomic clocks that provide extremely accurate time. The time information is placed in the codes broadcast by the satellite so that a receiver can continuously determine the time the signal was broadcast. The signal contains data that a receiver uses to compute the locations of the satellites and to make other adjustments needed for accurate positioning. The receiver uses the time difference between the time of signal reception and the broadcast time to compute the distance, or range, from the receiver to the satellite. The receiver must account for propagation delays, or decreases in the signal's speed caused by the ionosphere and the troposphere. With information about the ranges to three satellites and the location of the satellite when the signal was sent, the receiver can compute its own three-dimensional position. An atomic clock synchronized to GPS is required in order to compute ranges from these three signals. However, by taking a measurement from a fourth satellite, the receiver avoids the need for an atomic clock. Thus, the receiver uses four satellites to compute latitude, longitude, altitude, and time.

Accuracy Limitation

There are a number of physical processes that limit the fundamental accuracy of GNSS. In general, there are ways of mitigating these effects but there are limitations according to the particular design of the system and individual GNSS receivers. The main causes of positional error are due to:

- Variable atmospheric delays
- Multipath errors from signal reflections
- Ephemeris errors (errors in stated satellite position)
- Satellite clock errors
- Inherent errors in measuring pseudorange
- Corrections needed for special relativity effects

- Movement of the GNSS receiver
- Interface, jamming and spoofing
- Malfunctions in the GNSS on-board equipment or at a navigation system level

- **Variable Atmospheric Delays**

The signals from the satellite enter an ever-increasing density of the Earth's atmosphere. This gradually slows the speed of the signal and generally bends the direct ray of energy travelling between the satellite and the receiver. These effects are known as "*refraction". This* puts an extra delay in the signal that distorts the measured range. The atmosphere is conventionally divided into two layers, the ionosphere and the troposphere.

The ionosphere typically lies from about 50 km. to over 1,000 km. above the Earth's surface. It has very low density but the atmospheric particles are ionized (electrically charged) by incident high energy particles from the sun. Electrons are displaced from atmospheric molecules creating positively charged molecules and free negatively charged electrons. The signal delay is dependent on the density and spread of the ionized particles. The effect on the signal depends on numerous parameters, including:

- The angle of signal incidence on the ionosphere
- The time of day
- The sun spot cycle (which effects the output of ionizing particles from the Sun)
- The local effects of the Earth's magnetic field
- Chaotic disturbances in the detailed structure of the ionosphere
- The frequency of the GNSS signal.

All of these introduce errors into the pseudorange measured by a GNSS receiver. The complexity to predict or measure ionospheric delay means that the error induced is usually ignored by most GNSS receivers. However, it can lead to errors in the measurement of pseudorange of 3-15 meters for a satellite at the zenith and 9-45 meters for satellite blow 10°. On the other hand, GNSS Augmentation Schemes can provide estimates of ionospheric effects to help improve accuracy. In particular, the use of localized differential GNSS, can remove much of the error.

The troposphere forms the lower levels of the atmosphere up to about 30 km. There are two significant effects on the measured pseudorange, known commonly as *wet* and *dry delays.* The wet delay is caused by water molecules while the dry delay is caused by other molecules in the atmosphere.

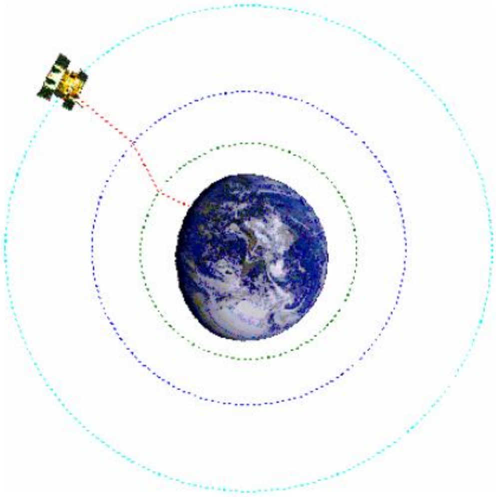


Fig. 7.3: Ionosphere and Tropospheric Refractions

- **Multipath errors from signal reflections**

The signal from the satellite may not arrive directly at the GNSS receiving antenna but may be reflected by other objects. This increases the pseudorange range from satellites by an unpredictable amount. In many instances there may not be a direct path from a satellite to the receiving antenna. Signals from such satellites can then only enter the receiving system from a reflection, probably off the ship's superstructure. This will cause varying positional errors depending on the actual alignment of the ship to the satellites being used for position estimation.

Multipath errors are not eliminated by differential or other augmentation systems. Installers of GNSS on ships should take care in the positioning of the antennas. A poorly positioned antenna should be high on the list of suspected reasons if there are consistent problems with GNSS accuracy and an appropriate engineer's advice should be sought. It should be noted that it is an IMO requirement that: *the antenna design should be suitable for fitting at a position on the ship which ensures a clear view of the satellite constellation*.

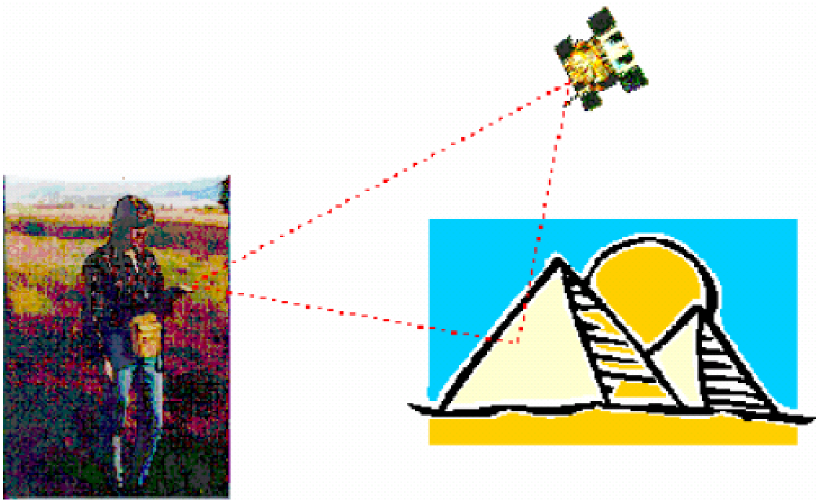


Fig 7.4: Multi-path errors

- **Ephemeris errors (errors in stated satellite position)**

Accurate positional information of the satellite used in a GNSS fix is a necessity. The term *ephemeris* is used for this data as it reflects its use for the predicted motion of the Moon, planets and comets. It also emphasizes that the data is a prediction, rather than an instantaneous measurement. From regular data supplied by the satellites themselves the ephemeris of each satellite can be internally calculated by the GNSS receiver to an accuracy of about two meters; and this error can be reduced by using augmentation techniques such as differential.

- **Satellite clock errors**

Although the atomic clocks in the satellites are extremely precise and kept in time to UTC from ground transmissions, there are still residual errors. For GPS their typical absolute accuracy is better than about 7 nanoseconds (7 x 10^{-9} seconds or 7 billionths of a second), which is equivalent to about 2 meters range accuracy. The positional error incurred can be reduced by augmentation techniques.

- **Inherent errors in measuring pseudorange**

All methods of measuring pseudorange have inherent accuracy issues from processes that induce random fluctuations into the measurements. These arise from both natural and synthetic processes. Engineers use the term *noise* to identify such effects, which include the signal generation process in the satellite transmitter, noise within the receiver system and noise effects that distort the signal during its path from the satellite to the receiver. Noise is a random, unpredictable effect, unlike the other errors which all create measurement biases. Despite the effects being unpredictable in detail, the general uncertainty in measurement can be estimated for a particular system.

- **Corrections needed for general and special relativity effects**

GNSS is unusual in that it is a practical application where relativity has measurable effects. In particular, the weaker gravitational field experienced by the satellites make their atomic clocks run faster as observed from the Earth, as predicted by the theory of General Relativity. To compensate for this effect, the satellite clocks have to run very slightly slow. As an example the frequency that GPS clocks are based on is 10,230,000 Hz, the satellite clocks run at 10,299,99.99545 Hz to compensate for General Relativity. Application of the theory of Special Relativity shows that the relative velocity of the satellite to a receiver has a very small effect on the measured pseudorange. Some high performance receivers compensate for this but its magnitude is generally less than 1 centimeter. There are, therefore, no residual effects of relativity that concern most users.

- **Movement of the GNSS receiver**

Basic measurements of position internally generated by a GNSS receiver are valid at a particular time in the past because of the *latency* (time delay) in computing and displaying the result. Also, because of the random errors (inherent errors), positional information is normally ‘averaged’ to improve positional accuracy. Since the normal use of GNSS for navigation is on non-static platforms, such as ships, the averaging has to be performed to take into account the movement of the platform between measurements. This is achieved by a mathematical technique known as *Kalman Filtering*. This considerable improves the accuracy when the platform is moving at a constant speed and can also remove any latency. However, during a maneuver that involves acceleration, including changes of direction (which is an angular acceleration) the Kalman Filter, unless aided by inertial sensors – which is presently unusual on a commercial ship – can output positions that are relatively inaccurate and also exhibit the effects of latency.

- **Interface, jamming and spoofing**

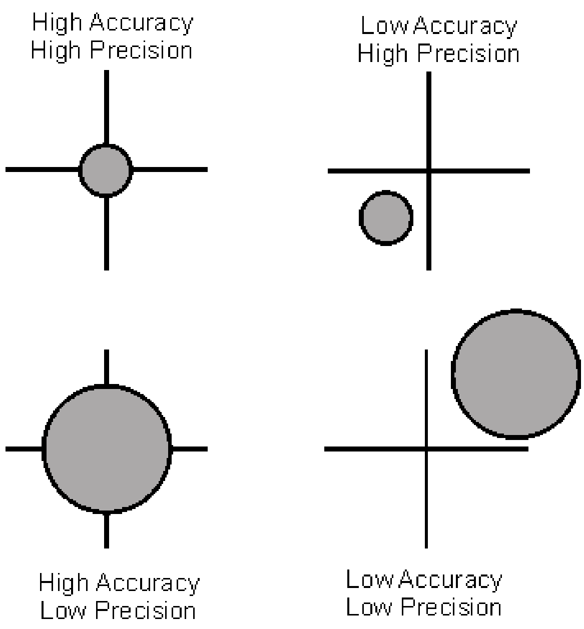
Interference to the received GNSS signal is the unintentional disruption of receiver performance due to electromagnetic radiation from other sources. This can lead to the complete loss of positional information.
Jamming is purposefully generated electromagnetic radiation that is intended to deny effective use of the system.
Spoofing is the intentional transmission of satellite-like signals that can cause GNSS receivers to generate an erroneous position.

GPS Accuracy and Precision

The term GPS accuracy is a rather over-used term. However it can be said that the levels of GPS accuracy are extremely high these days, even for civilian use GPS units.
It is also worth defining the difference between accuracy and precision:

- ***GPS accuracy:*** The accuracy refers to the degree of closeness the indicated readings are to the actual position.
- ***GPS precision:*** Is the degree to which the readings can be made. The smaller the circle of unknown the higher the precision.

The difference between accuracy and precision is described visually in the diagram on the right.



In addition to potential systematic (fixed) errors which (in principle) may be compensated, position fixing is inevitably affected by a certain level of scatter. To a certain extent, position accuracy obeys the laws of statistics. Any statement on the accuracy of a given position normally contains a statement

- on the radius ‘r’ of the error circle and
- on the probability ‘p’

of the resulting position fix falling within this error circle. The probability value is known as ‘confidence level’. Statements on accuracy without giving the confidence level are incomplete. For example, the probability that the actual position of the ship is within a circle of error of a 20m radius around the measured (displayed) position is 95%. The full meaning of the statement ‘**accuracy 20m (95%)**’ is:

Put another way, there remains a potentially dangerous uncertainty: given 20 position fixes, there is a probability that one of them (5%) will fall outside the error circle of 20m radius. If the radius of the error circle is taken 3 times as large (e.g. say 60m for GPS), the probability of the ship being within the circle will rise to 99.9%. The confidence level of accuracy is alternatively often expressed as '2 drms' (twice distance root mean square) which more or less corresponds to the 95% probability level. On an electronic chart display, the positional uncertainty is generally expressed by a double circle as own ship's symbol to remind the user of the limits of position fixing accuracy and integrity.

Measurement of Error

The following table describes the common GPS accuracy measures and their respective definition.

Dimension	Accuracy measure	Probability %	Typical Usage	Definition
1	rms	68	Vertical	Square root of the average of the squared errors.
2	CEP	50	Horizontal	A circle's radius, centered at the true antenna position, containing 50% of the points in the horizontal scatter plot.
2	rms	63-68	Horizontal	Square root of the average of the squared errors
2	R95	95	Horizontal	A circle's radius, centered at the true antenna position, containing 95% of the points in the horizontal scatter plot.
2	2drms	95-98	Horizontal	Twice the rms of the horizontal errors.
3	rms	61-68	3-D	Square root of the average of the squared errors
3	SEP	50	3-D	A sphere's radius, centered at the true antenna position, containing 50% of the points in the 3-dimensional scatter plot.

Reference: "GPS Accuracy: Lies, Damn Lies, and Statistics", Frank van Diggelen, GPS World January 1998.

Fig. 7.5: Common GPS accuracy measures

Position Dilution of Precision (PDOP) and Horizontal Dilution of Precision (HDOP)

The actual positioning of the satellites in the sky used to determine own position is extremely important to the quality of the computed position. For instance, if the satellites were very close together the ranges would all be very similar and small errors in these estimations would generate large errors in the calculation of own position. It is similar to the issue of taking visual sights. If two objects on which sights are being taken are close in bearing angle, or are at near reciprocal angles, then a position fix taken that uses these objects as a reference is likely to have a greater error than if they were close to right angles to each other.

Position Dilution of Precision (PDOP) is effectively calculated as the reciprocal of the pyramidal volume that is enclosed by constant length vectors pointing at the direction of each satellite from the receiver, normalized to the maximum achievable volume.

The usefulness of PDOP is if a system, such as a particular GNSS, gives a particular error in position when operating at the optimum geometry of satellites, the error will multiply by the value of PDOP when operating with other satellite distributions. So, if the accuracy of a system is 10 meters when the PDOP is 1, it will be 30 meters when the PDOP equals 3. For GNSS it is generally considered that a PDOP of less than 3 or 4 is very good and up to about 8 is acceptable but above 9 is poor. However, the important issue is whether the estimated accuracy is suitable for the navigation task in hand and it not, what action should be taken.
Other Dilution of Precision terms are also used. HDOP refers to Horizontal Dilution of Precision. This is the effect of a (three-dimensional) PDOP as measured only with respect to the Earth's surface – and is therefore the horizontal component of PDOP. This gives an indication of the precision of the position fix from the GPS based on the satellites it is currently using and their geometry. The lower the value is, the more accurate the positions fix. An HDOP of 2.0 or less is considered good and 20.0 and above will result in a loss of fix.

Meaning of DOP Values

DOP Value	Rating	Description
<1	Ideal	This is the highest possible confidence level to be used for applications demanding the highest possible precision at all times.
1-2	Excellent	At this confidence level, positional measurements are considered accurate enough to meet all but the most sensitive applications.
2-5	Good	Represents a level that marks the minimum appropriate for making business decisions. Positional measurements could be used to make reliable in-route navigation suggestions to the user.
5-10	Moderate	Positional measurements could be used for calculations, but the fix quality could still be improved. A more open view of the sky is recommended.
10-20	Fair	Represents a low confidence level. Positional measurements should be discarded or used only to indicate a very rough estimate of the current location.
>20	Poor	At this level, measurements are inaccurate by as much as 300 meters with a 6 meter accurate device (50 DOP × 6 meters) and should be discarded.

Differential Global Positioning System (DGPS)

Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy, from the 15-meter nominal GPS accuracy to about 10 cm in case of the best implementations.

DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount. The digital correction signal is typically broadcast locally over ground-based transmitters of shorter range. (The **pseudorange** (from pseudo- and range) is an approximation of the distance between a satellite and a navigation satellite receiver — for instance Global Positioning System (GPS) receivers.)

The term can refer both to the generalized technique as well as specific implementations using it. For instance, the United States Coast Guard (USCG) and Canadian Coast Guard (CCG) each run such a system in the U.S. and Canada on the longwave radio frequencies between 285 kHz and 325 kHz near major waterways and harbors. The USCG's DGPS system is nationwide and comprises 86 broadcast sites located throughout the inland and coastal portions of the United States including Alaska, Hawaii and Puerto Rico.

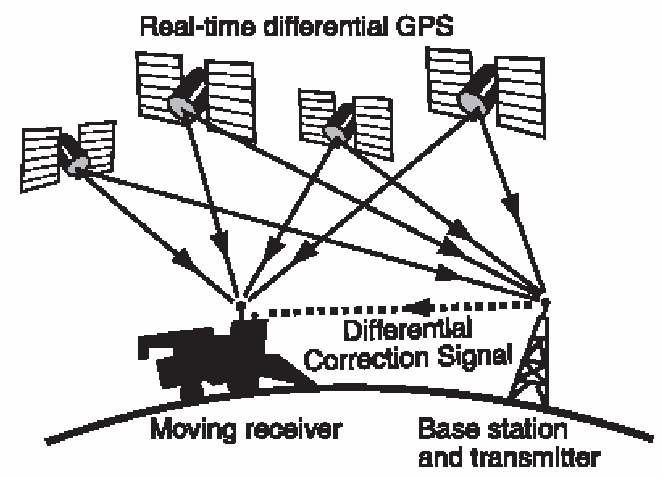


Fig. 7.6: DGPS Structure

A similar system that transmits corrections from orbiting satellites instead of ground-based transmitters is called a Wide-Area DGPS (WADGPS) or Satellite Based Augmentation System.

DGPS Sources

• Wide Area Augmentation System (WAAS, real- time)

- Is a navigation system composed of satellites and ground stations that improve the quality of the Global Positioning System (GPS). Normally, an air navigation aid to augment the GPS with the goal of improving its accuracy, integrity, and availability.

    a. **Accuracy** of the WAAS specification requires it to provide a position accuracy of 7.6 meters (25ft) or better (for both lateral and vertical measurements), at least 95% of the time.

b. **Integrity** of a navigation system includes the ability to provide timely warnings when its signal is providing misleading data that could potentially create hazards.
c. **Availability** is the probability that a navigation system meets the accuracy and integrity requirements. Before the advent of WAAS, GPS could be unavailable for up to a total time of four days per year. The WAAS specification mandates availability as 99.999% throughout the service area, equivalent to downtime of just over 5 minutes per year.

• OmniStar communication satellites (real-time)

- Is a satellite based augmentation system (SBAS) service provider. OmniStar corrections signals are proprietary, and a subscription must be bought from the OmniStar Corporation to receive a subscription authorization.
- OmniStar uses geostationary satellites in 8 regions covering most of the landmass of each inhabited continent.
- To access the OmniStar solution the user must have an OmniStar capable receiver. OmniStar capable receivers are available from a number of GPS manufacturers. They use a control hub where reference station data is checked, formatted, and uploaded to a geostationary satellite for rebroadcasting to subscribers.

• Nationwide Differential GPS (NDGPS) radio beacons (real-time)

- The Purpose of the NDGPS is to provide accurate positioning and location information to travelers, emergency response units, and other customers. The system provides 1-to 3-meter (m) navigation accuracy. This will improve collision notification systems, enable cooperative vehicle-highway collision-avoidance systems, and provide more accurate route guidance systems.

- Currently, the GPS services offers only 4-to 20-m navigational accuracy. For many land transportation uses, this accuracy is insufficient. NDGPS offers a 1-to 3-m radio navigational service that meets the needs of many more transportation users. NDGPS improves the accuracy and integrity of the GPS by constantly monitoring and broadcasting corrections to the GPS service. This is accomplished through a network of ground facilities called reference stations.

- Differential GPS uses the fixed location of a reference station to determine the inaccuracy of the satellite signal. The location derive from the satellite signal is compared to the reference station. That difference or inaccuracy can then be transmitted to nonstationary receivers. By comparing the inaccuracy to the satellite signal, the nonstationary receivers can then accurately determine their location.

• Local base station (real-time or post-processed)

- There are many permanent GPS base stations currently operating throughout the world that provide the data necessary for GPS. Base station data is consistent (i.e., with no gaps due to multipath errors) and very reliable because base stations usually run 24 hours, seven days a week, it is ideal for many GIS and mapping applications.

• Ground Based Augmentation System

- Ground Base Augmentation System (GBAS) referred to as the Local Area Augmentation System (LAAS). The GBAS uses signals from the Global Positioning System (GPS) to develop an extremely accurate navigation signal. The GBAS is a ground-based augmentation to GPS that focuses its service on the airport area (approximately a 20-30 mile radius) for precision approach, departure procedures, and terminal area operations. It broadcast its correction message via VHF radio frequencies.

7.2: Coordinate GPS Antenna Position Settings

Ownship Dimensions

Certain physical parameters concerning own ship need to be known by ECDIS. In particular this includes length and beam, so that when the chart in use is of sufficiently large scale, the vessel may be shown at scale size.

At large scales it is important that the position fix reference point on the ship is also defined. When overlaying radar data, the position of the radar antenna(s) also has to be known so that the radar overlay is accurately aligned onto large-scale charts. Furthermore, on more modern systems, positions may be referenced to the *Consistent Common Reference Point* (CCRP), which is normally the main conning position. On sophisticated systems, there may be more than one CCRP defined, in order to assist conning from secondary positions, such as the bridge wings.

Required dimensional parameters on a sophisticated set-up could therefore include the following:

- Length
- Beam
- Positions of primary and secondary navigation receiver antennas
- Position of radar antennas 1 and 2
- Conning positions (CCRP) 1, 2 and 3.

Positional information will include distances along and athwart the centerline.

It is quite common for this data only to be set by installation and service engineers. This is because of the interaction it can have with other equipment on the bridge, such as the positioning receivers, radars and integrated navigation system. Unfortunately, not all ECDIS equipment allows users even to view the set-up information, making checks difficult.

For ECDIS equipment that allow users to edit these parameters, great care should be taken that this data remains correct, although for most systems such data is password-protected. A careful user of easily alterable systems should check that the information is valid at the start of the watch. It could have been changed in error by a previous user or for a special purpose. If the OOW notes that this information appears to be incorrect, the Master should be informed before it is corrected.

7.3: Position System

Position Page
The field of a position sensor contains a label (here FURUNO and MX 200) which indicates the name of the sensor; a status (primary/secondary/off) which indicates if the sensor is used or not; position at conning position and local datum; speed and course which has (mag) if the course is referenced to magnetic north. A DGPS position sensor has additional text Diff, if differential signal is in use. Latitude and longitude values will appear in red and with additional text in the following conditions:

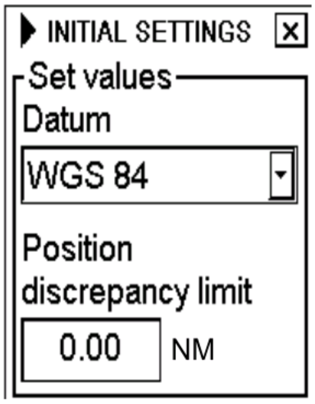
- Kalman filter has excluded the sensor from its estimated position. Additional text is "Excluded".
- Received position from position sensor is in another datum as set to be received in the ECDIS.Additional text is "Datum".
- If position sensors have position discrepancy active. Additional text is "Discrepancy".

- Chart Alignment – Alignment is automatically selected if the operator has defined position offset by using the chart align feature. The offset values are given in nautical miles and degrees. If position alignment is used, the operator is reminded of it every 30 minutes by the alert.
- Dead Reckoning – The system automatically selects dead reckoning if there are no valid and selected position sources and if there are valid and selected speed and course sources. If the system has selected dead reckoning, then the operator can enter a next WPT position for the ship in the Lat. and Long. fields.
- Kalman Filter – The Kalman filter calculates estimated position using all valid and selected position, speed and course sensors.

7.4: Determine Fix Quality (status) of GPS

- Performance of the Position Fixing System within ECDIS
  Because of the high importance of reliable position fixing used with electronic charts, the following requirements hold (as addressed in the IMO Performance Standards for ECDIS):
  - To allow real-time positioning and fast decision-making, the ship’s position should be derived from a continuous positioning system (e.g. once every second);
  - Whenever possible, a second independent position fixing system should be provided, and ECDIS should be capable of identifying discrepancies between the two systems;
  - ECDIS should provide an alarm when the input from the position-fixing system is lost;
  - ECDIS should also repeat, but only as an indication, any alarm or indication passed to it from a position-fixing system;
  - Comparison of the chart image with a radar image may provide a warning that the main positioning system is in error.

- Tracking the Discrepancy Between PS1 and PS2
  You can activate the alert "2007 Position discrepancy" from the Initial Settings dialog box. The alert is active between primary position and any secondary positions. Note that the alert is also effective between your ship's position and any positions, since ECDIS compass position discrepancy between position used by system (your ship's position) and any individual position sensor selected as primary or secondary source of position. To deactivate the alert set limit as 0.00.



- Check Ship's Position by a Second Independent Means
  The practice of prudent seamanship requires that the Watch Officer does not rely on any single means of position fixing. Also for a satellite navigation system such as GPS, it is good seamanship to check its performance regularly by other means of position fixing. Accuracy and integrity should be monitored by status indications, plausibility or comparisons. If there are significant differences, the mariner should determine the cause of the discrepancy. The following possibilities for position monitoring should be considered:
  - Visual and radar navigation/fixes using a marker on the electronic chart;
  - Validity of run between fixes; dead reckoning;
  - Comparison of position against a known position (e.g. when at pier);
  - Status of automatic indicators and alarms;
  - GPS Satellite number, status and HDOP (geometry indicator);
  - Reception of DGPS broadcast signals (SNR);
  - Comparison of displayed GPS receiver data vs. ECDIS data;
  - Comparison with a second position sensor (e.g. GPS2);
  - Comparison of electronic chart and radar overlay;
  - Query/display of the error circle radius.

  In principle, the ship’s position can be manually adjusted (‘off-set’), but this should happen only if the cause of the divergence is unambiguously established (e.g. by different horizontal datum).

CH. 8: BASIC NAVIGATION

The general tasks of navigation are route planning, route monitoring and route documentation. This includes the ability:

- To determine the optimal route, taking into consideration the navigational and economical points of view;
- To ensure that the route can be safely sailed, e.g. by identifying navigational aids, marking positions lines, fixing the ship’s position, corrections of course and speed.

The functions of electronic charts are not limited, as when using a paper chart, to display the information of the charts on the screen. Being complex integrated navigation and information system, electronic charts make it possible to present selected information from a complex data set together with navigation sensor information – all to support ship's navigation through route planning and monitoring in a very effective way. Therefore, they also include all basic navigational functions, as well as safety-relevant planning, monitoring and control functions. Generally, the functions relate to:

- Basic settings (e.g. display category, highlight danger);
- Navigational elements (e.g. own ship, Variable Range Marker (VRM), lines of position);
- Specific functions for route planning (e.g. creation of legs, route check);
- Specific functions for route monitoring (e.g. look-ahead, past track).

And to achieve compliance with international regulations, a ship may navigate with ECDIS as the primary means of navigation if:

- Sufficient official data adequate for the intended passage is installed (ENC and RNC)
- the installed ECDIS is type approved
- a second type approved ECDIS is installed as a backup (or there is a full paper chart backup)
- adequate generic and type specific training has taken place
- any additional requirements laid down by Flag State are fulfilled.

Additionally, a ship may navigate paperless if it utilizes ENCs to fulfill the chart requirement (ie official vector charts only).

All of these developments require navigating officers to adopt and adhere to new watchkeeping routines and practices with the use of ECDIS. The ECDIS Procedures Guide provides a framework and supporting background and checklists to help companies implement best practices in the use of ECDIS onboard their ships.

8.1: Display Categories and Information Layers

The Electronic Navigational Charts (ENC) commonly referred to as 'vector charts', are layered with digital information enabling the mariner to electronically interrogate features on the chart such as buoys, navigational marks, traffic separation schemes (TSS) and safety contours with detailed information displayed for the user.

ENCs provide the mariner with a clear display of the navigational situation without distorting the chart display when reducing the chart scale.

Masters and officers should be aware of the limitations of ENC data, including the dangers of overreliance on ECDIS. **<u>ENC data can cause operator error particularly as electronic navigational charts contain digitally layered information.</u>**

The IHO has issued a circular warning that ECDIS may not display some isolated shoal depths when operating in ‘base’ or ‘standard display’ mode. As a result, route planning and monitoring alarms may not always be activated when approaching such dangers and may result in groundings.

The Standard page contains chart features defined by IMO that comprise a standard display.

Mariners must ensure their ECDIS display has been set-up properly to the circumstances and conditions so that it includes all information necessary for safe navigation. ECDIS display modes that are set-up in ‘base’ display mode may remove vital information. The ECDIS display should set-up appropriate to the environment the ship is operating in. This may differ between navigational environments such as pilotage, coastal, deep sea and anchoring situations as layers of data may need to be added or removed depending on the situation.

The Other 1 and Other 2 pages contain chart features for which you can control visibility and that are not part of IMO-defined standard display.

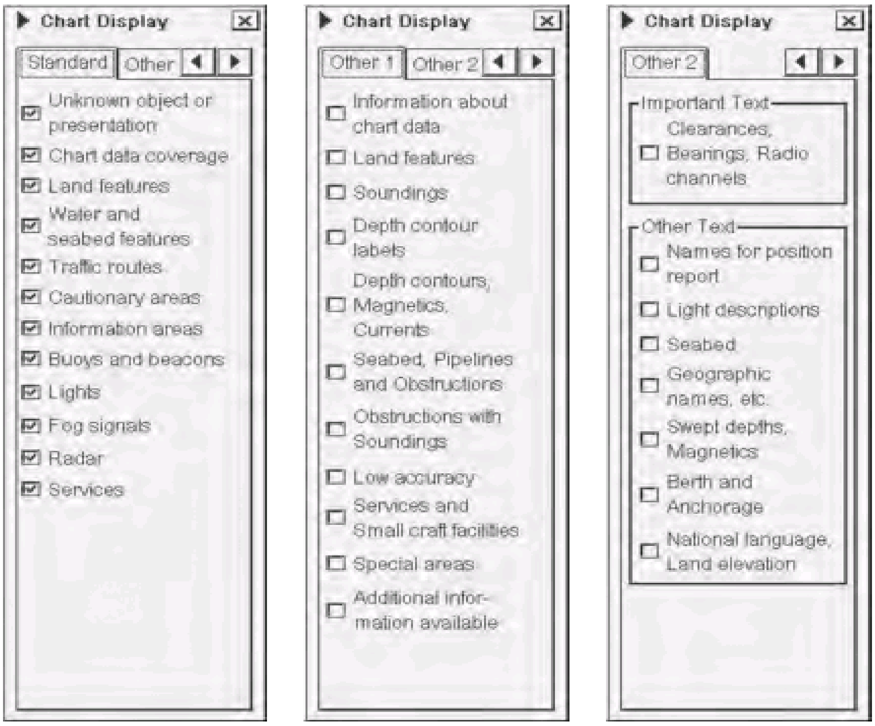


Fig. 8.1: Chart Display options

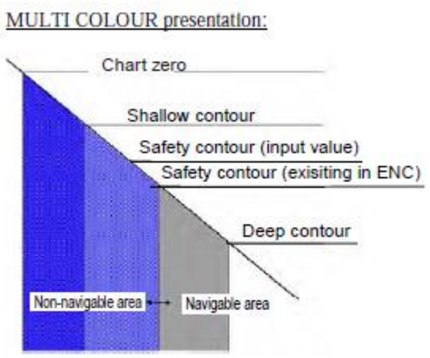
Note 1: To use the Info request feature, which provides information for cursor selected chart feature, the associated chart feature must be turned on from the Standard page.
Note 2: To navigate between the menus in the Chart Display dialog box, click the appropriate arrow tab with the left mouse button.

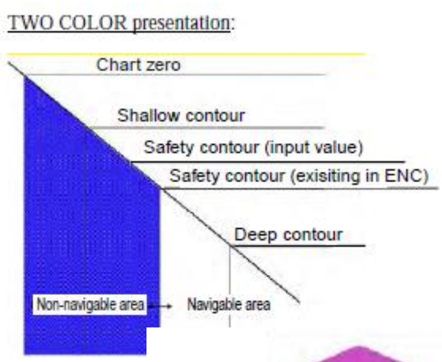
8.2: Monitoring Vessel's Safety

During a voyage, ECDIS should be in continuous use as the major aid for route monitoring. Route monitoring is basically comparing the progress of the voyage against the pre-prepared plan and monitoring the safety of any necessary deviations from the plan. These deviations may be because of collision avoidance action or any other tactical maneuvers, to maintain safety or react to specific requests from coastal authorities. If time allows a pre-identified deviation from the originally planned route should be the subject of an amendment to the route plan, and also to have the approvals stated within the Bridge Instructions. Even if the voyage plan is being updated on route, ECDIS will continue to provide certain automatic route monitoring facilities, although such updates are best performed on a second (back-up) ECDIS.

- Verifying GYRO Settings
- Manual heading should only be used in an emergency, when no other heading source is available.
- A rate gyro is always automatically selected.
- Verifying SPEED Settings.
- Manual speed should only be used in an emergency, when no other speed reference is available.
- If neither Log nor Dual log is available, you can use radar as the source for speed and course.
- Setting Values for Safety Contour and Deep Contour

Colours used for depth presentation is controlled by setting values for Shallow Contour, Safety Contour and Deep Contour.



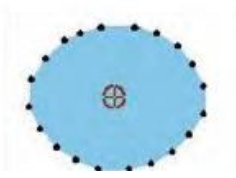


- Set a safe depth value from sea level with regards to Isolated Dangers

Depending on the safety parameters, the display mode and the position of an object, its presentation style might change in order to indicate a danger.

Isolated danger of depth less than the safety contour in safe water

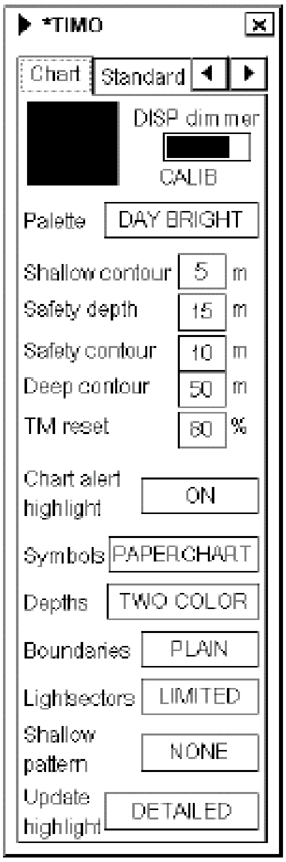
Example – Isolated Dangers:



The symbol for an “isolated danger” will change depending on the safety contour. If the isolated danger has a safe passing depth less than your safety contour it will be considered “Not safe to pass over” and the top warning symbols will be in use.

If the safe passing depth is more than your safety contour, the isolated danger becomes insignificant and is only shown if selected in chart layers and according to the blue symbol. The same happens if the isolated danger lies in waters already declared non navigable by the safety contour.

Chart Page: (Example)



- **Black and grey color symbol**
This symbol is used to verify that you can distinguish black (frame of symbol) and grey (inner part of symbol) colors with current contrast and brilliance settings.
- **Dsp Dimmer**
Use this control to adjust dimming of display.
Note: Use of the brightness control may inhibit visibility of information at night.
- **Palette**
Select appropriate palette for the display depending on the brightness of the bridge.
- **Shallow contour**
Set value of shallow water contour.
Safety depth
Set value of safety depth. Spot soundings below the safety depth are highlighted.
- **Safety contour**
Set value of safety contour. Visible safety contour is equal to set value or if the contour of set value is not available then the visible safety contour is next deeper contour than safety contour.
Note: The system uses safety contour also for chart alerts.
- **Deep contour**
Set deep water contour.
TM reset
In the true motion mode, own ship moves until it reaches the true motion reset borderline (set here), and then it jumps back to an opposite position on screen based on its course. Set the limit for TM reset (in percentage).
- **Chart alert highlight**
Enable or disable highlight of chart alerts.

8.3: Route Monitoring Functions

Electronic charts particularly vector systems contain a wide range of functions for monitoring the ship's voyage. This can be from simple visual indications to automatic monitoring alarm functions. On the ECDIS display, effective visual route monitoring can be performed

- by presenting the sea area in the most appropriate available scale;
- by adapting the contents of the displayed chart to the actual situation (ship's draught, day or night, etc.)
- by functions such as 'Past Track' and radar image overlay;
- by special functions such as event marking (e.g. 'VTS log-in'), emergency maneuvers (e.g. person-overboard) etc..

Concerning automatic alarms, effective route monitoring is essentially provided

- by the 'Look-Ahead' functions for ENC objects and
- by track-related alarms ('Cross track limit exceeded').

During route monitoring, ECDIS must show own ship's position whenever the display covers that area. Although the navigator may choose to "look-ahead" while in route monitoring, it must be possible to return to own ship's position with a single operator action. Key information provided during route monitoring includes a continuous indication of vessel position, course, and speed.
Additional information that ECDIS or ECS can provide includes distance right left of intended track, time-to-turn, distance-to- turn, position and time of "wheel-over", and past track history.

As specified in Appendix 5 of the IMO Performance Standard, ECDIS must provide an indication of the condition of the system and its components. An alarm must be provided if there is a condition that requires immediate attention. An indication can be visual, while an alarm must either be audible, or both audible and visual.

The operator can control certain settings and functions, some of the most important of which are the parameters for certain alarms and indications, including:

- Cross-track error: Set the distance to either side of the track the vessel can stray before an alarm sounds. This will depend on the phase of navigation, weather, and traffic.
- Safety contour: Set the depth contour line which will alert the navigator that the vessel is approaching shallow water.
- Course deviation: Set the number of degrees off course the vessel's heading should be allowed to stray before an alarm sounds.
- Critical point approach: Set the distance before approaching each waypoint or other critical point that an alarm will sound.
- Datum: Set the datum of the positioning system to the datum of the chart, if different.

And lastly, when monitoring a route, the prudent navigator must always maintain a check on the integrity of the displayed position of own ship. When the source of the displayed position is the own ships GNSS, there is always a possibility that the position displayed may not coincide with the ship's actual position in relation to the chart or the charted hazards. A check may be made quite simply by utilizing one or any of the following:

- Manual position fixing (visual/Radar);
- Look out of the window;
- Comparison of ARPA overlay of a fixed mark with the charted position;
- Comparison of radar overlay with conspicuous land or fixed targets;
- Observation of a parallel index on the radar display to monitor comparison with planned track;
- Monitoring the depth shown by echo sounder where appropriate;
- Checking the track history.

Navigational Elements and Parameters

ECDIS equipment is required to display commonly required navigational elements and parameters as given in the list below. The display of many of these is defined by IMO in SN/Circ.243.

1. Own ship
   - Past track with time marks for primary track
   - Past track with time marks for secondary track
2. Vector for course and speed made good
3. Variable range marker and/or electronic bearing line
4. Cursor
5. Event
   - Dead reckoning position and time (DR)
   - Estimated position and time (EP)
6. Fix and time
7. Position line and time
8. Transferred position line and time
   - Predicted tidal stream or current vector with effective time and strength
   - Measured tidal stream or current vector with effective time and strength
9. Danger highlight
10. Clearing line
11. Planned course and speed to make good
12. Waypoint
13. Distance to run
14. Planned position with time and date
15. Visual limits of lights arc to show rising/dipping range
16. Position and time of 'wheel over'

CH. 9: HEADING AND DRIFT VECTORS

9.1: Activate Vessel's Motion Vectors

Displaying True or Relative Speed Vectors

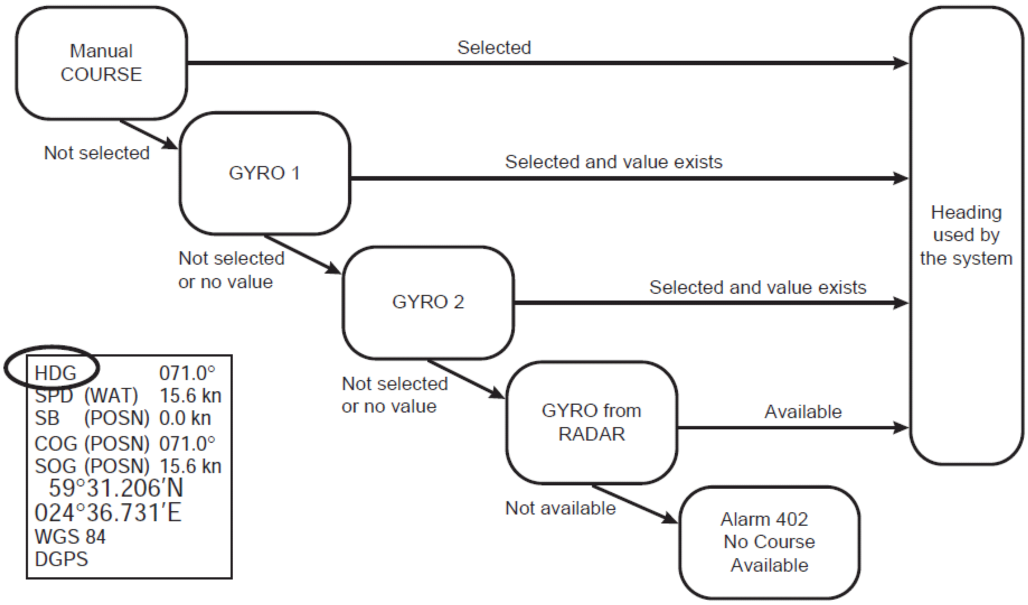
Targets vector can be displayed relative to own ship's heading **R Vect** or with reference to the North (true vector stabilized to Ground, **T Vect(G)** or True vector stabilized to Sea, **T Vect(S)**. All presentation modes can be used with relative motion or true motion.
Vector time (or the length of vectors) and presentation mode can be set on the information area. Place the cursor on the item you wish to change, spin the scrollwheel to select setting then push the scrollwheel.

9.2: Vessel’s Course and Speed from the Positioning System

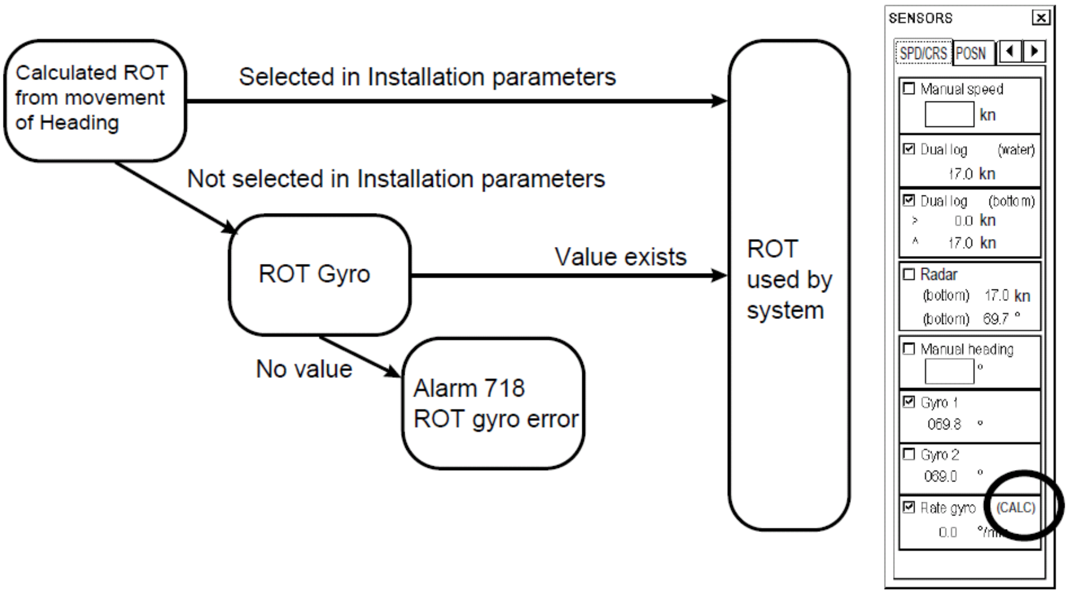
Source of SOG, COG, Speed, Heading, ROT, Drift and Docking Speed Components

The figure below shows how various sources of navigation data are selected. "SOG, COG" is speed over ground and course over ground, respectively. "Speed" is speed over water. "Drift" is the difference between speed over water and speed over ground. Docking speed components are bow speed (transversal), stern speed (transversal) and center speed (longitudinal).

Heading used by the system is shown at the upper right corner of the ECDIS display. In the example shown below, heading is received from a gyrocompass and it is shown without additional text, meaning the value is referenced to true North. Additional gyro-related text which may appear are "(mag)" if the value is referenced to magnetic North, "(man)" if the value has been manually entered; or "(corr)", which is displayed in red, if the value includes gyro correction.



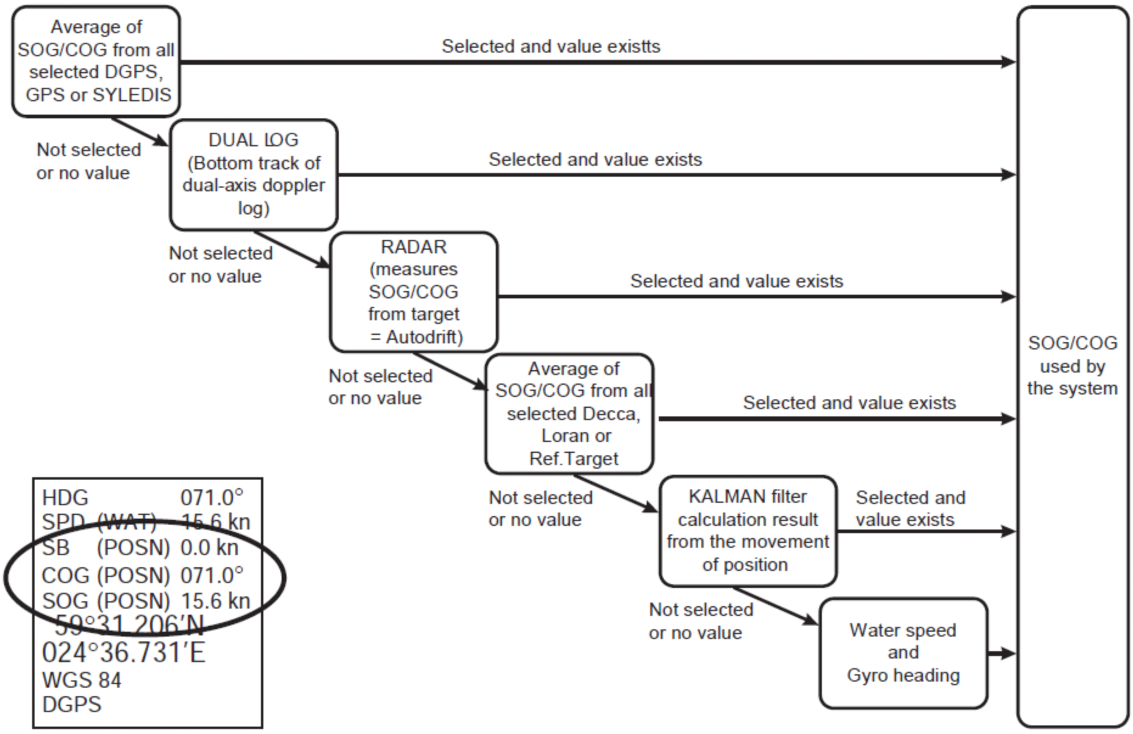
ROT used by the system is shown in the Speed/Course page of the Sensors dialog box. The Rate Gyro field shows the text "(calc.)" when the system calculates ROT from movement of heading. No text is shown when the value is received from an ROT gyro.



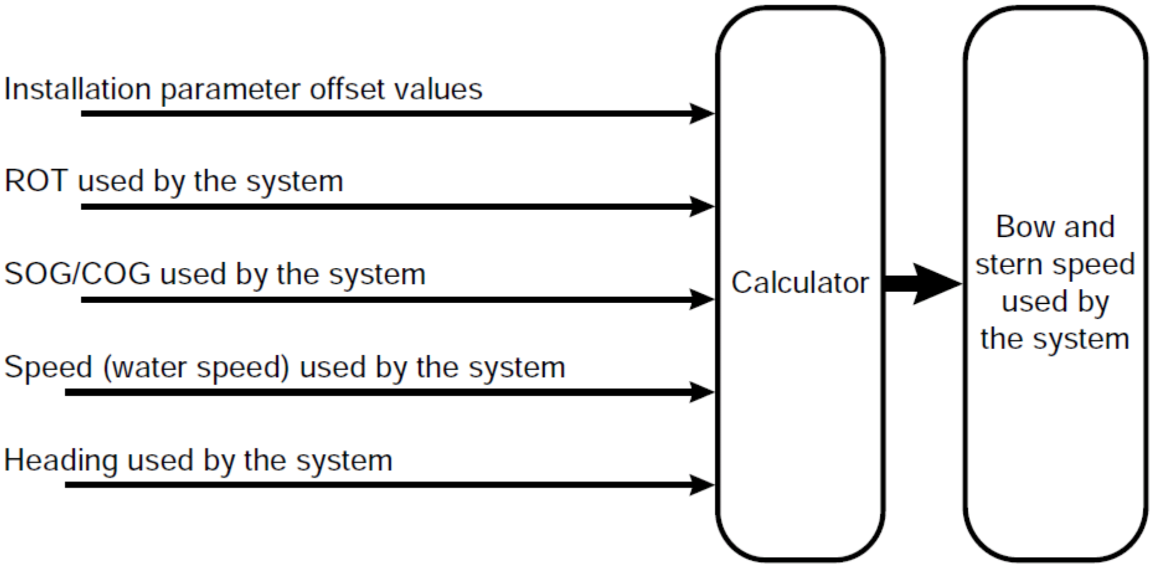
SOG/COG used by the system is shown at the upper right corner of the ECDIS display. In the example below, COG and SOG are from selected position sensors and this is indicated with the text "(pos)". Other text which denote SOG/COG source are

(BOT):	Bottom tracking dual-axis log
(CALC):	Speed calculated from SOG
(WAT):	Water tracking log
(RDR):	Mixed sources of COG and SOG in the connected radar

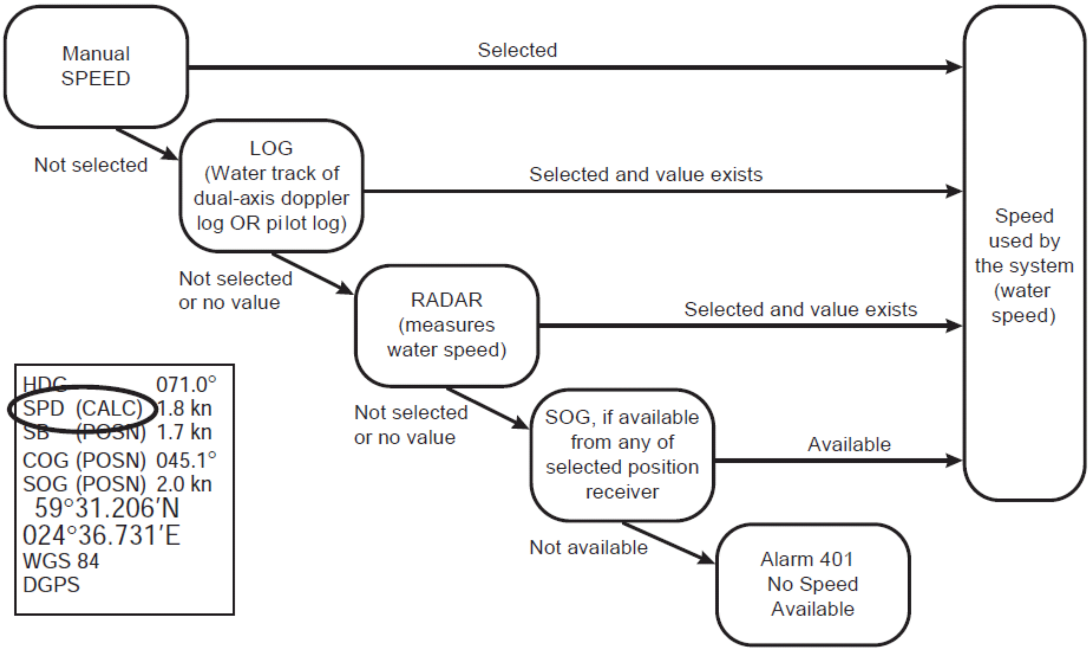
(POSN): Average of selected position sensors
(FILTER): Kalman filter
(MAN): Manual entry
Note that (pos), (bot), (wat) and (man) could come from direct interfaces of the system or from the connected radar.



The figure below show the source of docking speed components used for the predictor.

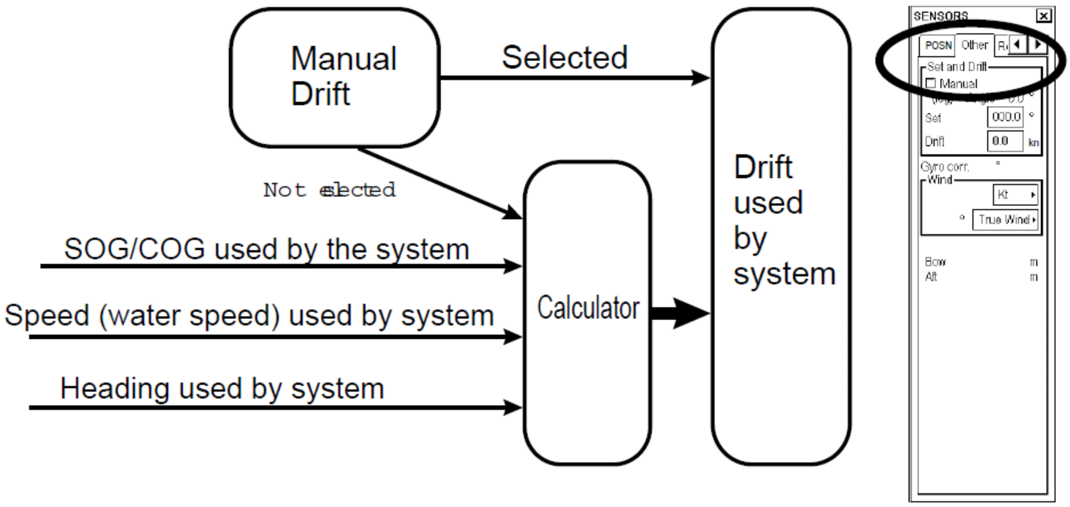


The figure below shows the source of water speed used for drift calculation.



Drift used by the system is shown in the Other page of the Sensors dialog box. In the example below, set and drift have been entered manually since the Manual box is checked. Other text which may appear to show source of set and drift are:

(LOG): Log or dual-axis log
(POSN) Position sensor
(FILTER): Kalman filter
(MAN): Manual entry.



9.3: Interpreting the Movement of the Vessel

Tidal current is the periodic horizontal movement of the water's surface caused by the tide-affecting gravitational forces of the Moon and Sun. Current is the horizontal movement of the sea surface caused by meteorological, oceanographic, or topographical effects. From whatever its source, the horizontal motion of the sea's surface is an important dynamic force acting on a vessel.

Set refers to the current's direction, and drift refers to the current's speed. Leeway is the leeward motion of a vessel due to that component of the wind vector perpendicular to the vessel's track. Leeway and current combine to produce the most pronounced natural dynamic effects on a transiting vessel. Leeway specially affects sailing vessels and high-sided vessels.

It is difficult to quantify the errors discussed above individually. However, the navigator can easily quantify their cumulative effect by comparing simultaneous fix and DR positions. If there are no dynamic forces acting on the vessel and no steering error, the DR position and the fix position will coincide. However, they seldom do so. The fix is offset from the DR by the vector sum of all the errors.

When the navigator measures this combined effect, he often refers to it as the "set and drift". The set is the direction from the DR to the fix. The drift is the distance in miles between the DR and the fix divided by the number of hours since the DR was last reset. This is true regardless of the number of changes on course or speed since the last fix. The prudent navigator calculates set and drift at every fix.

- Set and Drift

Note that you can select manual drift only if there are no automatic sources for SOG and COG. In other words, you have neither a dual-axis log nor any position receiver available.

Angle = Difference between heading and COG
Spd = Speed component of the drift vector
Crs = Course component of the drift vector

Vector defined by (SOG and COG) is equal to vector sum of vectors defined by (SPD and HDG) and (set and drift).

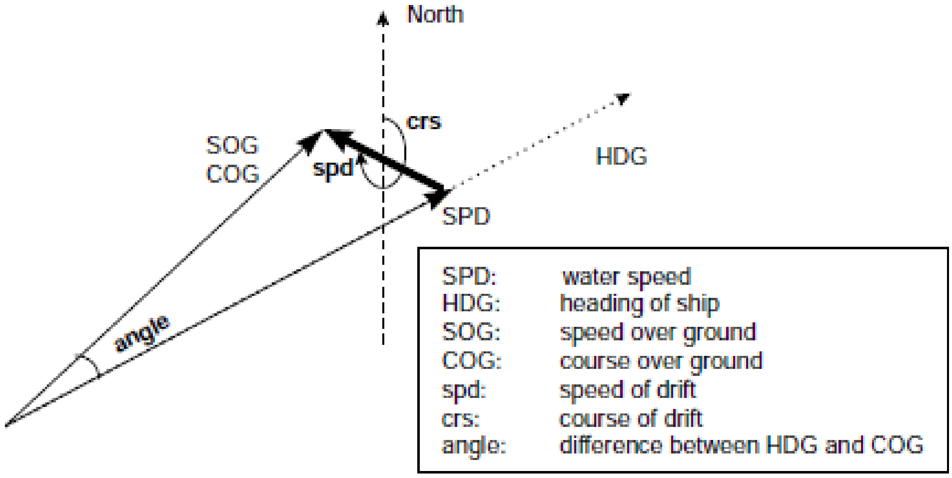


Fig. 9.1: Illustration of Set and Drift

9.4: Recognizing the Effects of Gyro Error

A **gyrocompass** is a type of non-magnetic compass which is based on a fast-spinning disc and rotation of the Earth to automatically find geographical direction. Although one important component of a gyrocompass is a gyroscope, these are not the same devices; a gyrocompass is built to use the effect of gyroscopic precession, which is a distinctive aspect of the general gyroscopic effect. Gyrocompasses are widely used for navigation on ships, because they have two significant advantages over magnetic compasses:

- they find true north as determined by Earth's rotation, which is different from, and navigationally more useful than, *magnetic* north, and
- they are unaffected by ferromagnetic materials, such as ship's steel hull, which change the magnetic field.

Errors of the Gyrocompass

The total of the all the combined errors of the gyrocompass is called gyro error and is expressed in degrees E or W, just like variation and deviation. But gyro error is unlike magnetic compass error, and is being independent of Earth's terrestrial magnetism.
The errors to which a gyrocompass is subject are speed error, latitude error, ballistic deflection error, ballistic damping error, quadrantal error, and gimballing error. Additional errors may be introduced by a malfunction or incorrect alignment with the centerline of the vessel.

- Speed error is caused by the fact that a gyrocompass only moves directly east or west when it is stationary (on the rotating earth) or placed on a vessel moving exactly east or west. Any movement to the north or south will cause the compass to trace a path which is actually a function of the speed of advance and the amount of northerly or southerly heading. This causes the compass to tend to settle a bit off true north. This error is westerly if the vessel's course is northerly; and easterly if the course is southerly. Its magnitude depends on the vessel's speed, course, and latitude. This error can be corrected internally by means of a cosine cam mounted on the underside of the azimuth gear, which removes most of the error. Any remaining error is minor in amount and can be disregarded.

- Tangent latitude error is a property only of gyros with mercury ballistics, and is easterly in north latitudes and westerly in south latitudes. This error is also corrected internally, by offsetting the lubber's line or with a small movable weight attached to the casing.

- Ballistic deflection error occurs when there is a marked change in the north-south component of the speed. East-west accelerations have no effect. A change of course or speed also results in speed error in the opposite direction, and the two tend to cancel each other if the compass is properly designed. This aspect of design involves slightly offsetting the ballistics according to the operating latitude, upon which the correction is dependent. As latitude changes, the error becomes apparent, but can be minimized by adjusting the offset.

- Ballistic damping error is a temporary oscillation introduced by changes in course or speed. During a change in course or speed, the mercury in the ballistic is subjected to centrifugal and acceleration/deceleration forces. This causes a torqueing of the spin axis and subsequent error in the compass reading. Slow changes do not introduce enough error to be a problem, but rapid changes will. This error is counteracted by changing the position of the ballistics so that the true vertical axis is centered, thus not subject to error, but only when certain rates of turn or acceleration are exceeded.

- Quadrantal error has two causes. The first occurs if the center of gravity of the gyro is not exactly centered in the phantom. This causes the gyro to tend to swing along its heavy axis as the vessel rolls in the sea. It is minimized by adding weight so that the mass is the same in all directions from the center. Without a long axis of weight, there is no tendency to swing in one particular direction. The second source of quadrantal error is more difficult to eliminate. As a vessel rolls in the sea, the apparent vertical axis is displaced, first to one side and then the other. The vertical axis of the gyro tends to align itself with the apparent vertical. On northerly or southerly courses, and on easterly or westerly courses, the compass precesses equally to both sides and the resulting error is zero. On intercardinal courses, the N-S and E-W precessions are additive, and a persistent error is introduced, which changes direction in different quadrants. This error is corrected by use of a second gyroscope called a floating ballistic, which stabilizes the mercury ballistic as the vessel rolls, eliminating the error. Another method is to use two gyros for the directive element, which tend to precess in opposite directions, neutralizing the error.

- Gimballing error is caused by taking readings from the compass card when it is tilted from the horizontal plane. It applies to the compass itself and to all repeaters. To minimize this error, the outer ring of the gimbal of each repeater should be installed in alignment with the fore-and- aft line of the vessel. Of course, the lubber's line must be exactly centered as well.

(http://www.globmaritime.com/technical-articles/marine-navigation/compasses/2840-errors-of-the-gyrocompass.html)

CH. 10: UNDERSTANDING CHART DATA

10.1: Terms and Definitions

In conjunction with the development of IMO Performance Standards for ECDIS, the International Hydrographic Organization has developed technical standards related to the digital data format, specifications for ECDIS content and display, and data protection.

- **IHO Special Publication 52 (S-52)** includes appendices describing the means/process for updating, color and symbol specifications, and a glossary of ECDIS-related terms.

- **IHO Special Publication 57 (S-57),** titled "IHO Transfer Standard for Digital Hydrographic Data". It includes a description of the data format, product specification for the production of ENC data, and an updating profile.
  The major components of S-57 Edition 3.1 are; Theoretical Data Model, Data Structure, Object Catalogue, ENC Product Specification, Use of the Object Catalogue for ENC.

  *Both the **IHO S-57 and S-52s'** are specified in the **IMO Performance Standards** for ECDIS.*

- **IHO Special Publication 58 (S-58)**, titled "IHO Recommended ENC Validation Checks". S-58 specifies the checks that, as minimum, producers of ENC validation tools should include in their validation software.

- **IHO Special Publication 62 (S-62)**, titled "ENC Producer Codes". S-62 provides a list of Agency Codes for all producers of ENCs, in particular Hydrographic Offices.

- **IHO Special Publication 63 (S-63)**, titled "IHO Data Protection Scheme". It includes a description of the IHO recommended ENC security scheme with two appendices relating to associated security test data sets and software kernel with source code for a reference implementation.

- **IHO Special Publication 66 (S-66)**, titled "Facts about electronic charts and carriage requirements". S-66 provides a high level guide to the production, maintenance and distribution of Electronic Navigational Charts (ENCs).

- **IHO Special Publication 100 (S-100**), titled "IHO Universal Hydrographic Data Model". S-100 is a new standard that will eventually supersede S-57. It complies with the ISO 19100 series of geographic standards and will support a greater variety of hydrographic-related digital data sources, products, and customers than S-57.

- **Electronic Chart Data Base (ECDB**) - is the digital database from which electronic charts are produced.

- **Electronic Navigation Chart Database (ENCDB)** - is the hydrographic database from which the ENC is produced.

- **Raster Navigation Chart (RNC)** – means a facsimile of a paper chart originated by, or distributed on the authority of, a government-authorized hydrographic office. RNC is used in these standards to mean either a single chart or a collection of charts.

- **Raster Chart Display System (RCDS**) - means a navigation information system displaying RNCs with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and if required, display additional navigation-related information. It uses official raster-formatted charts on an ECDIS system. Raster charts cannot take the place of paper charts because they lack key features required by the IMO, so that when an ECDIS uses raster charts it operates in the ECS mode.

- **System Raster Navigational Chart Database (SRNC)** - means a database resulting from the transformation of the RNC by the RCDS to include updates to the RNC by appropriate means.

10.2: Principal Types of Electronic Chart

The **electronic chart** is a relatively new technology that provides significant benefits in terms of navigation safety and improved operational efficiency. More than simply a computer display, an electronic chart is a real-time navigation system that integrates a variety of information that is displayed and interpreted by the Mariner. It is an automated decision aid capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards. The electronic chart represents an entirely new approach to maritime navigation.

We must first make a distinction between official and unofficial charts.

Official charts are those, and only those, Produced by a government hydrographic office (HO). Unofficial charts are produced by a variety of private companies and may or may not meet the same standards used by HO’s for data accuracy, currency, and completeness.


Fig. 10.1: Electronic Chart Display

1. The Electronic Charts

There are two basic types of electronic charts. Those that comply with the IMO requirements for SOLAS class vessels, known as the **Electronic Chart Display and Information System (ECDIS),** and all other types of electronic charts, regarded generally as **Electronic Chart Systems (ECS).**

Electronic Chart System (ECS) is a commercial electronic chart system not designed to satisfy the regulatory requirements of the IMO Safety of Life at Sea (SOLAS) convention. ECS is an aid to navigation and when used on SOLAS a regulated vessel is to be used in conjunction with corrected paper charts.

Electronic Chart Display and Information System (ECDIS) - is an electronic chart system which satisfies the IMO SOLAS convention carriage requirements for corrected paper charts when used with an ENC or its functional equivalent (e.g. NIMA Digital Nautical Chart.).

An electronic chart (EC) is any digitized chart intended for display on a computerized navigation system.

Electronic Navigational Chart (ENC) - is a vector chart data base published by a national hydrographic office for use in ECDIS. It meets international standards set by the IHO and IMO. ENC data is arranged according to S57 format and specifications.

2. Vector and Raster Charts

2.1 Vector Electronic Charts (ENC)

ENC's are vector charts that also conform to IHO specifications, as contained in Publication S-57. They are compiled from a database of individual items ('objects') of digitized chart data which can be displayed as a seamless chart. When used in an electronic navigation system, the data can then be reassembled to display either the entire chart image or a user-selected combination of data. ENC's are intelligent in that systems using them can be programmed to give warning of impending danger in relation to the vessel's position and movement.

Vector chart data is data that is organized into many separate files or layers. It contains graphics files and programs to produce certain symbols, points, lines, and areas with associated colors, text, and other chart elements. The programmer can change individual elements in the file and link elements to additional data. Vector files of a given area are a fraction the size of raster files, and at the same time much more versatile. The navigator can selectively display vector data, adjusting the display according to his needs. Vector data supports the computation of precise distances between features and can provide warnings when hazardous situations arise.

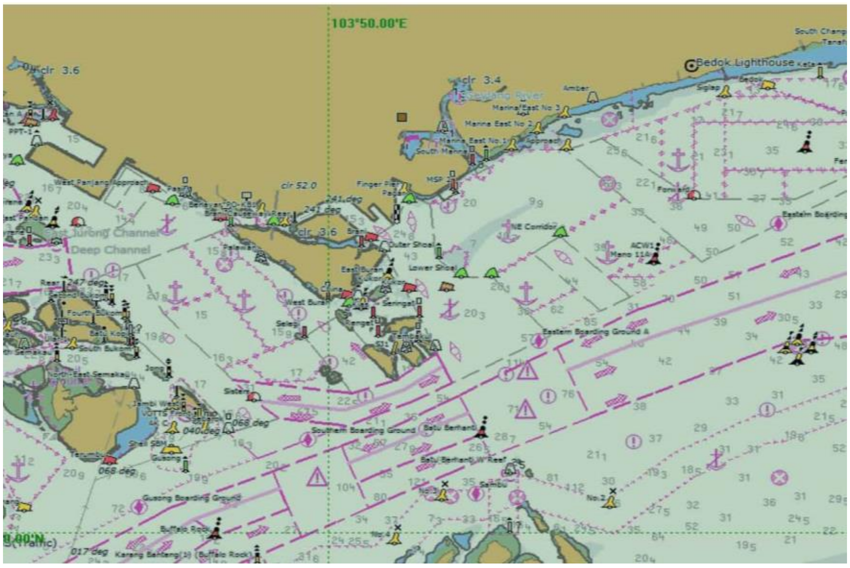


Fig. 10.2: Vector Chart

The chart data is organized into many separate files. It contains graphics programs to produce certain symbols, lines, area colors, and other elements. Vector files are smaller and more versatile than raster files of the same area. The navigator can selectively display vector data, adjusting the display according to his needs. Current IMO/ IHO standards for ECDIS recognize **only the vector format** as adequate.

2.2 Advantages of vector charts

- Chart information is stored in layers
- Users may customize chart displays to suit the particular needs of their vessels
- The chart data is seamless
- It is possible to select a safety depth and safety contour or to enter a specified area
- It is possible to interrogate charted objects for further information
- File sizes are up to 10 times smaller for vector charts than for raster charts.
- Vector charts can generally be displayed more quickly than raster charts
- Objects may be shown using different symbols to those used on paper or raster charts
- Charts may be rotated to any angle (course up reference)
- Charts may be shared with other equipment such as radar and ARPA

2.3 Disadvantages of Vector charts are:

- Vector charts are technically far more complex than raster charts
- Vector charts take longer and cost more to produce than raster chart
- Significant worldwide coverage will not be provided by official vector charts for many years
- Training in the use of vector charts likely to be longer and more costly than that for raster charts
- It is significantly more difficult to ensure the quality and integrity of the displayed vector data

2.4 Raster Nautical Charts

RNC's are raster charts that conform to IHO specifications and are produced by digitally scanning a paper chart image. The image may be either the finished chart itself or the stable color bases used in the multi-color printing process. The resulting digital file may then be displayed in an electronic navigation system where the vessel's position, generally derived from electronic position fixing systems, can be shown. Since the displayed data are merely a digital "photocopy" of the original paper chart, the image has no intelligence and other than visually, cannot be interrogated.

IMO resolution MSC.86 (70) permits ECDIS equipment to operate in a Raster Chart Display System (RCDS) mode in the absence of Electronic Navigational Charts. With raster data, it is difficult to change individual elements of the chart since they are not separated in the data file. Raster data files tend to be large, since a data point must be entered for every picture element (pixel) on the chart.

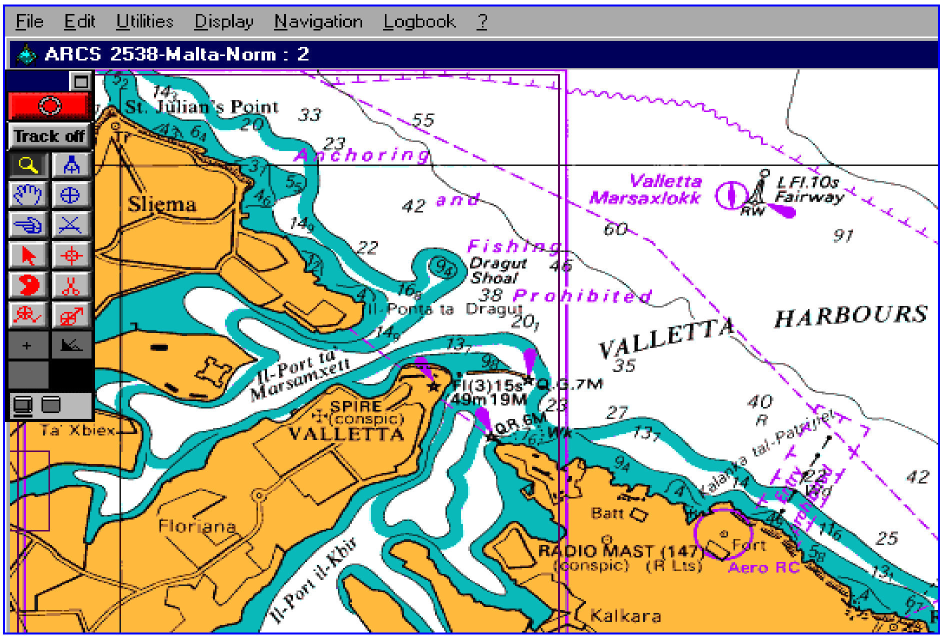


Fig. 2.3: Raster Chart

Raster chart data is a digitized "picture" of a chart comprised of millions of "picture elements" or "pixels". All data is in one layer and one format. The video display simply reproduces the picture from its digitized data file. With raster data, it is difficult to change individual elements of the chart since they are not separated in the data file. Raster data files tend to be large, since a data point with associated color and intensity values must be entered for every pixel on the chart.

2.5 The advantages of raster charts are:

- They are direct and exact copies of existing paper charts
- They use the same familiar colors and symbols as paper charts
- Their contents are as comprehensive, accurate and reliable as those of paper charts
- It is not possible for users to inadvertently omit significant navigational information from the chart display
- As the raster charts are simpler and easier to produce and update than official IHO compliant vector charts
- It is much easier to ensure the quality and integrity of the displayed data
- They cost less to produce
- Official produced raster charts are widely available. For example ARCS can now provide worldwide coverage
- Information from other nautical publications may be displayed in the same raster format
- With the addition of vector overlays and suitable software, it is possible to use raster charts for all the standard navigational tasks normally carried out with paper charts and to emulate some of the functions of ECDIS.

2.6 The disadvantages of raster charts include:

- Charts require significantly more storage room (than vector charts) on electronic devices. The storage for all raster charts for a single region may exceed the space required by vector charts for the entire country.
- The type size (font size) is fixed, so that letters and numbers become large when you zoom in and small when you zoom out, becoming less readable at both extremes.
- Zooming in too far to see your boat's position on a small scale chart may give a misleading impression - when a larger scale chart would be more accurate (vector charts automatically change scale).
- No information can be selectively removed or displayed at different zoom levels
- The system does not have any understanding of what it is showing you. It can superimpose the vessels satellite derived position but has no idea if you are in safe water or on land. In short, it cannot, directly, provide indications or alarms to indicate a warning to the user.

10.3: Vector and Raster Data Formats

1. Official Vector Data

In vector charts, hydrographic data is comprised of a series of files in which different layers of information are stored or displayed. This form of "intelligent" spatial data is obtained by digitizing information from existing paper charts or by storing a list of instructions that define various position-referenced features or objects (e.g., buoys, lighthouses, etc.). In displaying vector chart data on ECDIS, the user has considerable flexibility and discretion regarding the amount of information that is displayed.
An ENC is a vector data conforming to the IHO S-57 ENC product specification in terms of content, structure, and format. An ENC contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart. In general, an S-57 ENC is structurally layered data set designed for a range of hydrographic applications. As defined in IHO S-57 Edition 3, the data is comprised of a series of points, lines, areas, features, and objects. The minimum size of a data set is a cell, which is a spherical rectangle (i.e., bordered by meridians and latitudes). Adjacent cells do not overlap. The scale of the data contained in the cell is dependent upon the navigational purpose (e.g., general, coastal, approach, harbor).

2. Raster Data

Raster navigational chart (RNC) data is stored as picture elements (pixels). Each pixel is a minute component of the chart image with a defined color and brightness level. Raster-scanned images are derived by scanning paper charts to produce a digital photograph of the chart. Raster data are far easier to produce than vector data; however, raster nautical charts require significantly larger amounts of memory and present many limitations to the user compared against to vector charts.

The official raster chart formats are:

ARCS (British Admirality)
Seafarer (Australia)
BSB (U.S., NOAA/Maptech)

These charts are produced from the same raster process used to print paper charts. They are accurate representations of the original paper charts with every pixel geographically referenced. Where applicable, horizontal datum shifts are included with each chart to enable referencing to WGS84. This permits compatibility with information overlaid on the chart. *Note: Not all available charts have WGS84 shift information.* Extreme caution is necessary if the datum shift cannot be determined exactly.

Some of the limitations of RCDS compared to ECDIS include:

- Chart features cannot be simplified or removed to suit a particular navigational circumstance or task.
- Orientation of the RCDS display to course-up may affect the readability of the chart text and symbols since these are fixed to the chart image in a north-up orientation.
- Depending on the source of the raster chart data, different colors may be used to show similar chart information, and there may be differences between colors used during day and night time.
- The accuracy of the raster chart data may be less than that of the position-fixing system being used.
- Unlike vector data, charted objects on raster charts do not support any underlying information.
- RNC data will not trigger automatic alarms. (However, some alarms can be generated by the RCDS from user-inserted information.)
- Soundings on raster charts may be in fathom and feet, rather than meters.

The use of ECDIS in RCDS mode can only be considered as long as there is a backup folio of appropriate up-to-date paper charts.

10.4: ECDIS Data Base and Data Structure for Vector and Raster Data

ECDIS is thus more than an "electronic nautical chart". Nautical charts are in fact presented electronically, but in principle all kinds of chart - aviation charts, street maps, railway maps, etc. - could be presented on a computer display using the same methodology. ECDIS was initially developed for shipping, and thus the use of both terms as synonyms is entirely justified.

On the other hand, electronic chart presentation is only one aspect of ECDIS. ECDIS is also an information system. As an information system, ECDIS enables the user to call up information on the items displayed in addition to the graphics presentation. For an instance, a lighthouse, this is marked on the chart by a tower symbol. The system can give further information on this object, e.g. the fact that the tower has horizontal red/white stripes, is a 28 m high steel structure on a masonry base called "Roter Sand", and that it used to be manned but is no longer operational and is now preserved as a monument. The data may make it possible to call up a further text presenting a detailed history of our lighthouse. It may also be possible to view a digitized photo of this object. The amount and quality of the information available on the individual objects depends on how up-to-date, accurate and well maintained the data base is, not on the ECDIS itself.

The database for a typical electronic chart contains layers consisting of hydrography, aids to navigation, obstructions, port facilities, shoreline, regulatory boundaries and certain topographic features. Other layers such as communication networks, power grids, detailed bathymetry, and radar reflectivity can also be made available. This allows the user to customize his chart according to his particular needs, something a paper chart cannot do.

Whether a digital system uses a raster or vector database, any change to that database must only come from hydrographic office (HO) that produced the ENC. Corrections from other sources affecting the database should be applied only as an overlay to the official database. This protects the integrity of the official data base.

The chart database contains vector charts covering all navigable waters of the world. Most charts are updated with the latest Notices to Mariners as and when they are published. This also contains a tide prediction function for tidal nodes throughout the world. Tidal predictions can be graphically displayed for any chosen date. ENC chart database is fully compliant with the IHO S-57/3 specification, and ENC'S from Hydrographic Offices can be added in SENC format and displayed in ECDIS.

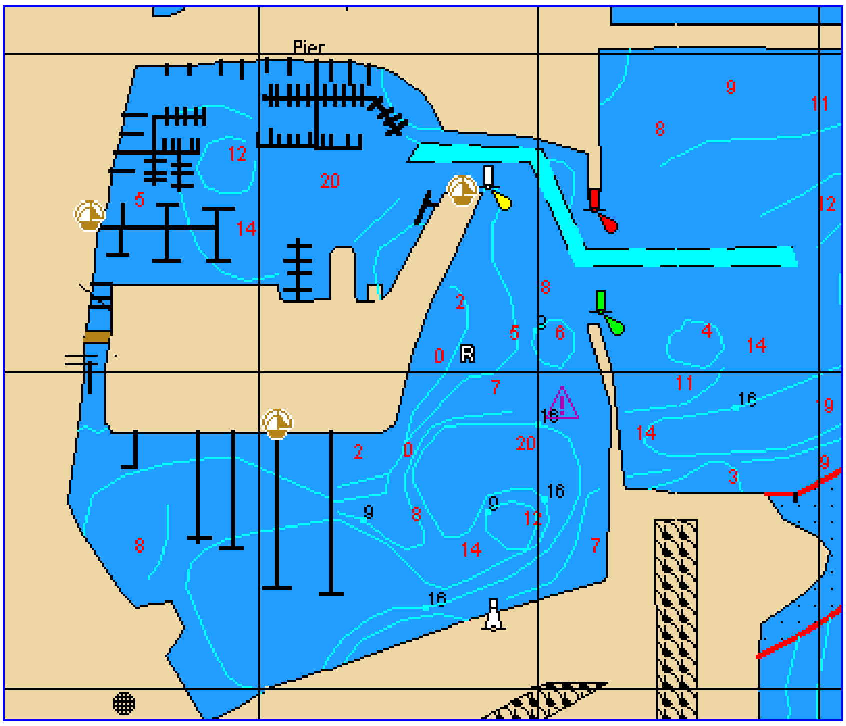


Fig. 10.5: ENC contains layers of topographic features

Dual Fuel Systems

A Dual Fuel System is one that is either an ECDIS or RCDS depending on the type of chart data in use. ENCs are scarce so there are few opportunities to use ECDIS whereas RNCs are available now in large numbers and can perform two important functions:

- Provide official electronic chart coverage for areas not covered by ENCs
- Provide link coverage between the ENCs that are available

Such a system is capable of taking advantage of the very latest in Electronic chart technology, using ENCs normal ECDIS mode where these charts are available, and using raster charts in RCDS mode when vector charts are not yet available.

For the future, a system should provide a choice of cartography, whilst ensuring that navigation calculations are consistent, regardless of the background chart.

10.5: ENC Production

ENC’s are digital data sets, standardized as to content, structure and format, issued for use with ECDIS on the authority of government authorized hydrographic offices and contain intelligent digital vector data produced as per standards and specifications laid down in IHO Publications S-57 and S-52. The ENC contains all the chart information necessary for safe navigation and contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which is considered essential for safe navigation.

The production of ENC’s is a complex and tedious process requiring considerable time and specific hardware, software and manpower. NHO has produced ENC’s from compilations and paper charts after updating these with latest data. The horizontal datum for the paper charts is Everest and for ENC’s, it is WGS-84.

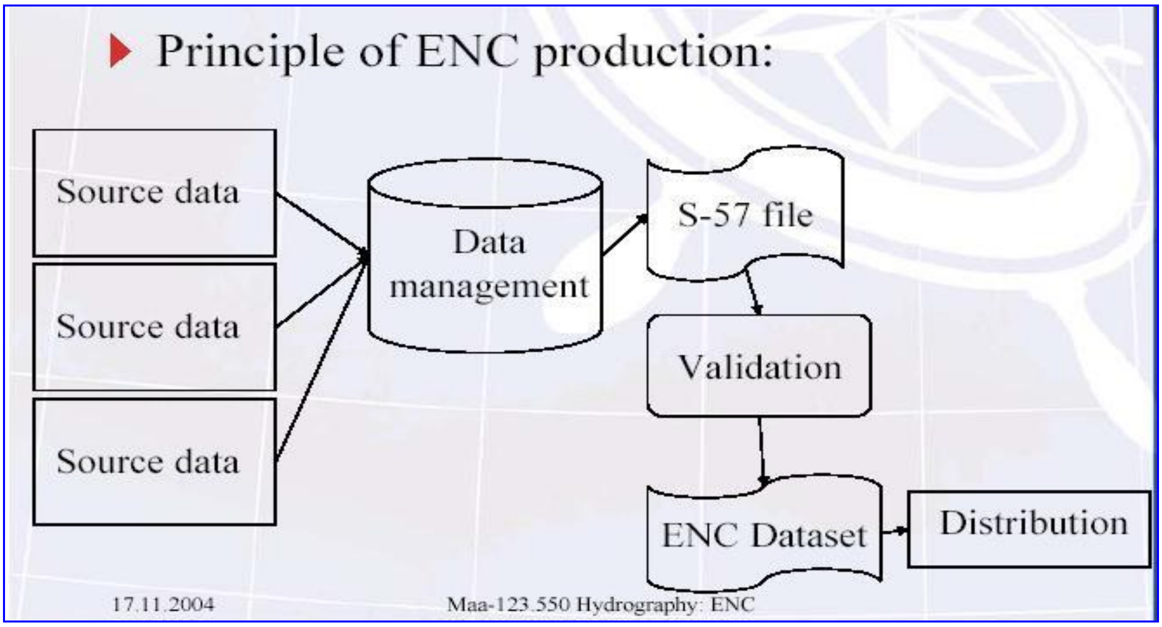


Fig. 10.6: Production of ENC Data

The various stages of ENC production from published chart/compilation/film are as follows:

1. Conversion from Analog data to Raster Image
Finally examined new compilation or a corrected film positive of a published paper chart is scanned through a scanner having 400 dpi resolutions to get a raster image in Tiff format.

2. Digitization
Digitization of various features of the chart as per cartographic requirement is a time taking task. Before digitization is done, a header file containing title, reference ellipsoid, geographical coordinates, central meridian, scale of the chart, projection etc., are defined. Raster Tiff file is then converted to CARIS Tiff. Then the Tiff file is cleaned and registered with header file. The digitization environment is feature based. The cleaned raster data stored in an editor displays the scanned image as a backdrop to the graphic window, after clicking on any line segment; the line will automatically be converted from raster to vector format. The standard editing commands editor can be used to capture other features like text, symbols, spot heights and soundings as per IHO standard.

3. Creation of Topology
The word “topology” describes the geometrical relationships between features in a digital chart. Graphical features are grouped together by their user numbers. When considering topological relationships, the feature to be processed is assigned a new user number. The file may contain several layers of related information which are grouped together by a common user number. Topology is built layer by layer, first, identifying the user number of the features (lines) to process, and then convert them into topological areas.

4. Metadata
The metadata is a group of special object classes which contains information about other objects. All features represent the attributes common to the whole ENC cell or part of the cell at compilation scale. Depth units are some of the object classes which belong to the whole ENC cell. These object classes are centroid features created by taking the whole chart as an area feature and transfer the centroid information to the area boundary. The maximum use of meta object is to be made to reduce the attribution on individual objects and maximum use of data set subfield is to be made to reduce attribution on meta objects.

5. Data Quality
In spite of the various checks done at different levels of data capture, the data quality is required to be ensured. The inconsistencies including missing mandatory attributes indicated by the translator and those observed during the examination of proof are removed. Any corrections found during the validation of ENC using international validation software are incorporated before the final conversion.

Once the ENC is created in accordance with the S-57 specification, it is to be transferred to a physical standard as the data structure created can not be ported to other systems on its own. It is then encapsulated using ISO 8211 standard. This standard provides a file based mechanism for the transfer of data from one computer to another, independent of model and operating system. It is independent of the medium used for such transfer. Further, it permits the transfer of data and also the description of how that data is organized. This is also part of S-57 specification, the process of converting the ENC data, into a free format, is also handled by the software used for generating ENC data set. The specification serves as a guide for uniformity of products by various H.O.'s and enables quality check and assurance of ENC's

Hydrographic Office Responsibilities for Producing ENCs
The responsibilities of Hydrographic Offices (HOs) for the production and distribution of ENCs are defined in the WEND (Worldwide Electronic Navigational Chart Database) principles. (M-3, Resolutions of the IHO). These note that:

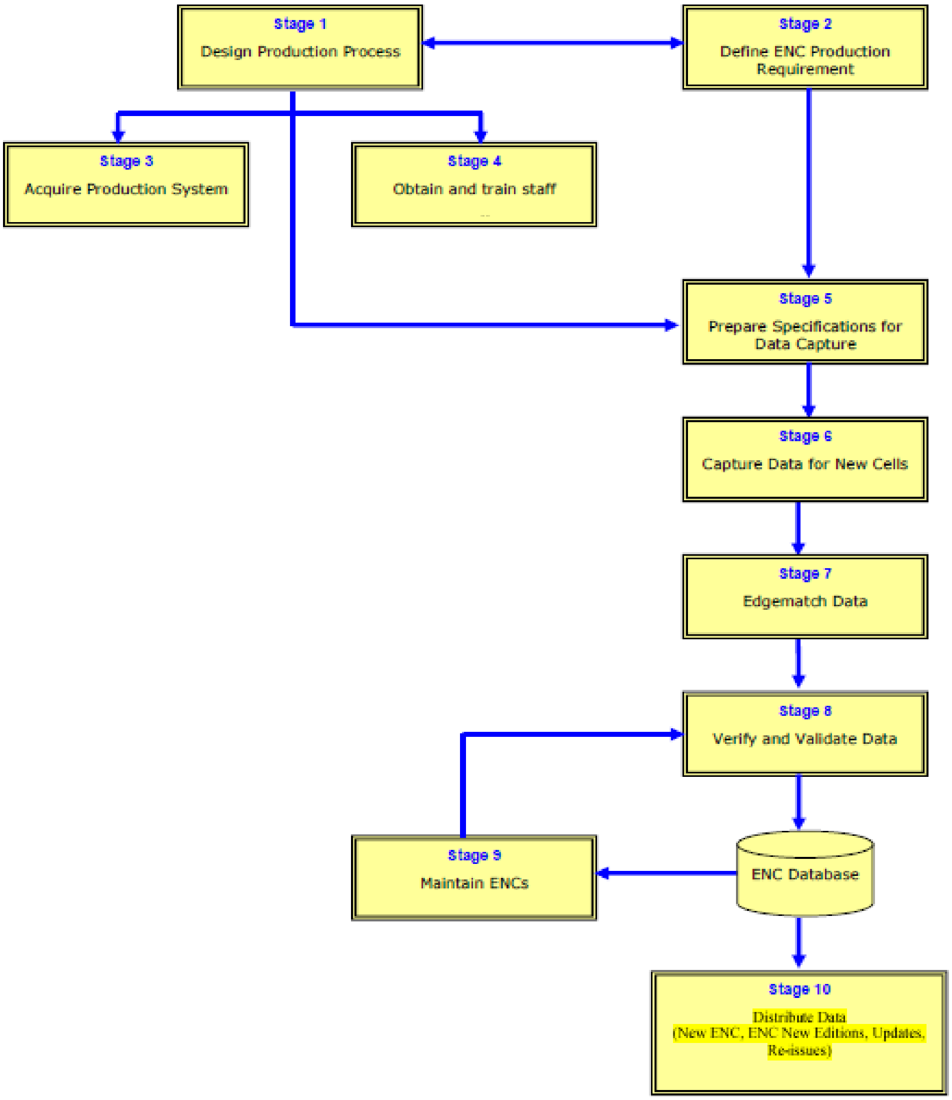
> "The purpose of WEND is to ensure a world-wide consistent level of high-quality, updated official ENCs through integrated services that support chart carriage requirements of SOLAS Chapter V, and the requirements of the IMO Performance Standards for ECDIS."

HOs are responsible for:

- The preparation and provision of digital data and its subsequent updating for waters of national jurisdiction.
- Ensuring that, mariners, anywhere in the world, can obtain fully updated ENCs for all shipping routes and ports across the world and that their ENC data are available to users through integrated services.

- Assuring the high quality of its ENC services through the use of a Quality Management System that is certified by a relevant body as conforming to a suitable recognized standard; typically this will be ISO 9001:2000.
- Ensuring compliance with all relevant IHO and IMO standards and criteria (including IHO S-57, IHO S-52, or their replacements).
- Providing timely updates to the ENC for the mariner; these should be at least as frequent as those provided by the nation for correction of paper charting.

KEY STAGES IN THE PRODUCTION OF ENC



ENC PRODUCTION AND DISTRIBUTION GUIDANCE

STAGE 1 – Design Production Process

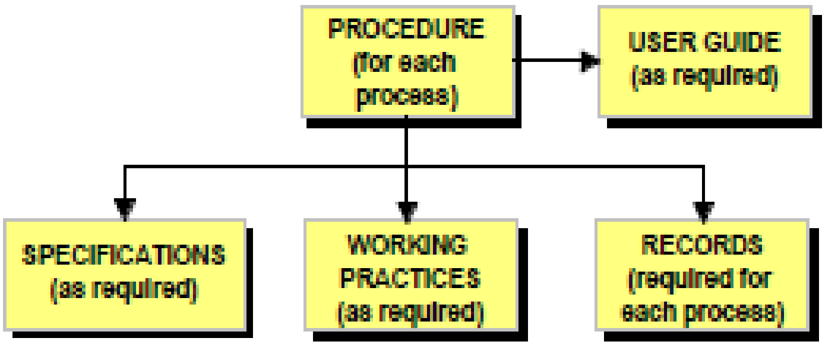
STEP 1 — Production Method

- Before the production process can be designed, it has to be decided which source material will be used for the ENCs.

  The decision as to which source material will be used will depend on several factors:
  - The quality and format (i.e. digital or analogue) of existing survey data. For example it may be more efficient and prudent to produce ENCs only from surveys completed to modern surveying standards.
  - The availability of accurate transformations for existing information to WGS-84 where required.
  - The existence of, or facilities to produce, rectified raster images of existing charts.
- Once it has been decided which source material will be used, a production process needs to be designed and a Quality Management System (QMS) for ENC developed to interface with existing production processes.
- Consideration should be given to ensure that the publication of ENCs and updates is co-incident with the publication of the equivalent paper chart information.

STEP 2 – A Quality System

- Procedures should be put in place to ensure that each stage of the production process is carried out correctly and consistently. These should be approved by a relevant body as conforming to a suitable recognised standard; typically this will be ISO 9001:2000.



ENC PROCESS DOCUMENTATION

- The production of ENCs demands a high level of quality control and quality assurance. It is important to bear in mind the difference between these two concepts:
  - Quality Control – those checks made on a product after production;
  - Quality Assurance – the overall set of processes, of which Quality Control forms a part, designed to ensure that a product is produced correctly and without errors.

STAGE 2 – Define ENC Production Requirement

STEP 1 — Identify Requirements

- While each nation has the responsibility for ENCs in its own waters, many aspects of the overall service to the mariner will be improved through their working within the relevant Regional Hydrographic Commission (RHC). This will expedite the completion of small scale coverage and the agreement of cell boundaries between nations. The WEND Task Group recommended that RHCs should:
  - Identify key shipping routes and ports within their regions
  - Identify charts covering these routes and ports to be captured as ENCs
  - Identify producer nations for the ENCs
  - Arrange for their production

  Wherever possible ENCs should be based on INT charts and the producer nations for the ENCs should be the same as the producer nations for the corresponding INT charts.

  If ENCs are to display correctly in an ECDIS it is especially important that there is no overlap of data within the same navigational purpose band. The ENC Product Specification3 makes it clear that such overlap must not occur. See also section 11 of Annex A.

  In addition to the agreement of boundaries, it is important that neighbouring nations agree, where possible, factors such as use of SCAMIN, contour intervals etc to provide a seamless depiction when possible.

STEP 2 — Produce Production Plan

- A national production plan then needs to be compiled to define:
  - which geographic areas are to be captured – note that this relates to actual areas of data coverage rather than the rectangular cell limits.
  - which navigational purposes are to be populated for each area
  - how the areas are to be divided into cells for each navigational purpose
  - the order of capture; e.g. larger scale cells first
- The production plan will be dependent on some of the following factors:
  - The reason for the requirement – Defence / SOLAS
  - Priority given to major ports and traffic routes, based on volumes of goods and number of passengers
  - Liaison with bordering countries to maximize production, improve efficiency and coverage, and to ensure cross-border consistency
  - Design considerations outlined below.

Cell Schema Design Considerations

Limits of ENC cells

- The HO has to decide how the limits of the planned ENC cells should be defined. The limits can be based on the existing limits of paper charts, or be defined by a rectangular grid.

- The ENC Production Specification, S-57 Appendix B.1, states that *"the geographic extent of the cell must be chosen by the ENC producer to ensure that the resulting dataset file contains no more than 5 megabytes of data. Subject to this consideration, the cell size must not be too small in order to avoid the creation of an excessive number of cells."*

  It also states that "cells must be rectangular". Within this, the actual data coverage can be any shape.

Compilation Scales

- It is recommended that the compilation scales for ENCs are based upon standard radar ranges.

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	1:45,000
1.5 NM	1:22,000
0.75 NM	1:12,000
0.5 NM	1:8,000
0.25 NM	1:4,000

  - Normally, the nearest larger standard scale should be used, e.g. an ENC produced from a 1:25,000 paper chart should have a compilation scale of 1:22,000
  - Exceptionally, if source material permits, the next larger scale may be used.
  - Where the source scale is larger than 1:4,000 or smaller than 1:3,000,000 then the actual scale should be used.

Navigational Purposes

- Dependent on its intended navigational purpose an ENC is assigned to one of the 6 navigational purposes defined in S-57:
  - Overview
  - General
  - Coastal
  - Approach

  - Harbour
  - Berthing
- S-57 Edition 3.1 does not define minimum and maximum compilation scales for each navigational purpose.

STAGE 3 – Acquire Production System

STEP 1 — Identify Requirement

- The capacity and capability of the production system required will depend on the production plan (see Stage 2) and on the extent to which data capture will be contracted out.
- In the broadest terms there are two types of production software:
  - Those which populate and maintain a database of ENC objects, attributes and attribute values in a format which is compatible with IHO Transfer Standard for Digital Hydrographic Data, S-57 (ENC Product Specification);
  - Those which create individual flat files each forming a single ENC cell.
- A Statement of Requirement (SOR) should be written to set out clearly the requirements of any contract. The SOR should include Key User Requirements, capability of the system, the number of workstations required, any support requirements, and any interfaces with other existing production systems. The contract could include hardware as well as software or just the latter for installation on existing infrastructure. See also Stage 4 regarding the potential for including training provision as part of this contract

STEP 2 — Invitation to Tender

- Once the required production capacity is known (see Stage 2) then an invitation to tender should be sent out to those companies identified as being capable of supplying a suitable system.
- The tenders rendered can then be evaluated against the criteria defined in the initial invitation.
- The contract can then be awarded to the selected company following the evaluation.

STEP 3 — System Installation and Testing

- Before acceptance, the system needs to be installed and tested to ensure that all contractual requirements have been met.

STEP 4 — Live Running

- When the supplier has demonstrated that the system performs in accordance with the specifications it can be contractually accepted and transferred to live running.

STAGE 4 – Obtain and Train Staff

STEP 1 — *Staffing Levels*

- Staffing levels need to be defined for the production of new ENC cells and the maintenance of existing cells. The staff requirement will be based on whether the decision is to contract out the data capture or capture data in-house, on the number of cells planned, and the proposed targets to achieve those plans.
- To assist with this planning the following provide some guidelines on the approximate timescales (based on UKHO ENC production) for the production and maintenance of cells, from initial preparation to final publication. These are based on production of ENC from paper charts with updates matching the paper chart Notice to Mariners service:
    - Production of New Cells = approximately 5 weeks of an operator‟s time for a full paper chart equivalent.
    - Production of New Editions = approximately 5 weeks.
    - Production of Updates = approximately 1 hour per update.

  Information from other HOs indicates that these figures may vary considerably depending on the complexity of the area, the verification and validation processes adopted and the experience of the staff involved.

STEP 2 — Determine Skill Levels

- The training needs depend on whether existing staff are to be re-trained or new staff recruited for ENC production.
- A Skills Analysis and Training Needs Analysis should be employed to determine the skills required for the job and the skill levels of the staff. Commercial companies can assist with this task. Where appropriate, reference should be made to Publication S-8; FIG/IHO/ICA „Standards of Competence for Nautical Cartographers‟.

  The following training may be required:
    - Chart Awareness Training, especially regarding navigational marks
    - ENC/S-57 Awareness training
    - Quality Assurance training, including quality control aspects
    - Production System Training
    - ECDIS training – for displaying ENCs to assess portrayal

STEP 3 —Identify Training Provider

- Once the requirement for training has been identified, the training provider needs to be determined. For Production System training, the system provider in most cases will provide the initial training and these needs to be specified within that contract. For Chart Awareness, QA and ENC/S-57 training, this could be provided internally by existing staff, or externally. Courses that are available internationally are listed in IHO Publication C-47, “Training Courses in Hydrography and Nautical Cartography”.

STAGE 5 – Prepare Specifications for Data Capture

STEP 1 — Published Specifications

- The IHO Transfer Standard for Digital Hydrographic Data, S-57, defines the content, structure and format of the data for ENC. Appendix B1 of the standard contains the Product Specification for ENC.
- Reference should be made to Appendix A (Object Catalogue) and Annex A to Appendix B1 (Use of the Object Catalogue for ENC), of S-57, which define how charted objects should be encoded for ENCs together with the "Recommendations for Consistent ENC Data Encoding" (Annex A)
- It should also be noted that S-57 is maintained by Maintenance Documents and any clarifications within these documents apply to ENCs complying with S-57 Edition 3.1 together with any Supplements that are extant. TSMAD, the IHO group responsible for maintaining and developing S-57, also produces ENC Encoding Bulletins and Frequently Asked Questions (FAQ) about ENC encoding issues. These are all available on the IHO website. TSMAD welcomes additional queries from member states or HOs about ENC encoding issues.

  All of these sources need to be searched when collating specifications relating to ENC data capture.

STEP 2 — Data Capture and Product Specifications

- The S-57 standard, although comprehensive, leaves it to HOs to decide what should be the content of the ENCs, what the limits of the cells should be, and which navigational purposes the cells should belong to.
- Supplementary Data Capture and Product Specifications should be produced to clarify the content and construction of ENC cells and the capture of ENC data, in addition to the recommended and mandatory requirements of S-57. As well as clarifications regarding content, these should include elements such as accuracy requirements and file naming conventions for cells and associated text and picture files.
- Size of data sets should be optimized and only necessary data should be included. This will facilitate remote distribution services.

STAGE 6 – Capture Data for New Cells

STEP 1 — Optionally, Place External Capture Contract

- If it has been decided that new cells are to be captured externally, a suitable contract needs to be agreed. This requires:
  - Definition of a suitable Statement of Requirements.
  - Identification of companies able to carry out the work; this can include a requirement that they be ISO9001:2000 certified.
  - Issuing of Invitations to Tender, including possible production of sample cell.
  - Evaluation of Tenders.
  - Selection of the contractor.

- Alternatively, other Hydrographic Offices may be able to offer production capacity, either on a commercial basis or as part of a wider bilateral agreement.

STEP 2 — Capture Data

- In order to facilitate capture, a "package" should be created for each cell containing all the necessary source information (For example, where capture is from paper charts: Raster Files; List of Lights; Overlays for clarification etc) for populating the cell.
- Depending on form of data capture used:
  - The package will be sent (via a secure route) to external contractor or HO; for facilitating this aspect, consideration should be given to sending such data in batches.
  - A suitably trained in-house operator will be tasked.
- The data must be captured in compliance with the recommended and mandatory requirements of S-57 and in accordance with any HO clarification or Data Capture Specifications.

STAGE 7 – Edge Match Data

STEP 1 —National Data

- Once a New Cell has been captured, or a New Edition of an ENC produced, it is important that the data on the cell border is aligned and matched with the corresponding data in any adjoining cells particularly of the same navigational purpose.
- When editing data on the border of cells to match adjoining data, it is important that the data is edited so that depth contours, depth areas etc. are adjusted on the side of safety.
- Editing should also only be done within a specific tolerance so that the accuracy of the data is not impaired to too great a degree.

STEP 2 — Between Nations

- In areas which include neighboring producer nations, HOs should co-operate to agree on cell boundaries. It is recommended that where advantageous, nations agree data boundaries within a technical arrangement based on cartographic convenience and benefit to the mariner.
- Suitable communications with neighbouring nations should be put in place to ensure data consistency across cell boundaries. These will include exchange mechanisms to allow access each other's ENCs.

STAGE 8 – Verify and Validate Data

STEP 1 — Production Systems and Procedures

- Thorough verification and validation procedures need to be in place to verify and validate ENC cells for content and accuracy, ensuring consistency with the IHO Data Transfer Standard S-57 Edition 3.1 together with any Supplements that are extant.

STEP 2 — Verification

- Cells need to be checked for content and capture accuracy. Typically this will take the form of a 100% check of the vector data against the source information so as to ensure that no charted objects or attributes have been omitted from the cell or captured in an incorrect position.

STEP 3 — Validation

- Validation software should be used to perform checks on the completed ENC cell. This is to ensure that an ENC is compliant with the S-57 ENC Product Specification. The minimum checks are defined within S-58.
- The validation process used should include software provided by a different supplier to that used for production. Some HOs use more than one validation software package as each tends to pick up different warnings and errors.

STAGE 9 – Maintain ENCs

STEP 1 — Establish Mechanism for ENC Updating

- Once an ENC cell has been produced and made available to the end user, then that data has to be maintained.
- The overall Quality Management System must include mechanisms for ENC updating designed to meet the needs of the mariner regarding safety of navigation.
- The processes for updating the paper chart are described in Part B-600 of S-4. The general principles of these processes apply equally to paper and electronic charts. The processes for updating the paper chart will need to have their counterpart in any updating process for the ENC.
- ENC Updates should be synchronized with paper chart equivalents; however, if paper chart production cycles are lengthy, the option of issuing ENC Updates and New Editions earlier should be considered together with any wider implications.

STEP 2 —Notice to Mariners (Updates)

- ENC Cells require updating to include details published in paper chart Notices to Mariners. These are in two forms: Chart Correcting Notice to Mariners (NM), and Temporary and Preliminary Notice to Mariners (T&P NM – see Annex B). Updating has to be completed within a rigid timescale for cells that have been issued to customers.
- ENC Updates must be produced to provide the ECDIS user with an updated SENC. As a guide, an ENC Update should not exceed 50 Kilobytes in size as some ECDIS experience problems with loading large update data sets.
- ENC Updates must be produced so as to replicate the corrections on the equivalent paper chart, and be produced at the same time whether that is weekly, fortnightly or monthly.

STEP 3 — New Editions or Notice to Mariners (NM) Blocks

- New Editions of the equivalent paper charts or paper chart NM blocks will require an ENC New Edition or an ENC Update. To optimize data transmission, updates are preferred where sufficient. Note: If is it reported from users that it is not possible to load an ENC update properly, a new edition should be created.

STEP 4 — ENC Re-issues

- Where it is considered that the number of updates to be applied to a base cell becomes too large, it is recommended that a Re-issue of the cell be produced. A Re-issue will optimize data transmission and avoid the heavy loading process of numerous updates for new subscribers to the ENC. It is at the data producers discretion as to what constitutes a large number of updates, but as a guide this may be considered to be between 20 and 50, and other factors such as the size of the updates. Existing subscribers will not be effected by the publication of a Re-issue (i.e. will not be required to load the Re-issue), and both new and existing subscribers will update their SENC from the time of the Re-issue through subsequent updates or New Editions..

STEP 5 — Distribution of ENC Data

- The timely distribution of the ENC data can be on CD-ROM, through the Internet, over INMARSAT, or by landline communication. However, see Stage 10 regarding wider distribution principles.

STAGE 10 – Distribute Data

STEP 1 — Identify Distribution System

- The distribution system provides the mariner with ENC data, in a timely process from the issuing HO to the end-user to support safe navigation. A considerable reduction in this time interval should be possible by taking advantage of existing digital and telecommunications technology.
- The distribution system ensures data integrity and protection. An S-57 error detection scheme applies for exchange of un-encrypted data. The IHO Data Protection Scheme (S-63) should be used for ENC distribution to end users.
- A Quality Management System should be established for the overall distribution system.
- When a mariner subscribes to an ENC service, the distribution system should provide the mariner with the latest ENC base cell (new cell, New Edition or re-issue) together with all updates which have been issued since the publication of this base cell.
- The distribution system should provide the existing subscriber with the last New Edition or re-issue and any updates issued since the last official update applied to the ENC in the SENC.
- The distribution system should provide information to the mariner as to the last update information (New Edition and update) available.

- The distribution system may use various transfer procedures depending on the media and channels. Transfer procedures should be suitable with end users capabilities to provide the update information to the SENC in the most effective way.
- Transfer procedures may use physical media or telecom (on line), on land or at sea.
- Delivery service may be scheduled on a regular base within a time interval adequate to support safe navigation and known in advance by end users, normally weekly, or on-demand. A nil message should be used if no update information is available.
- ENC data should at least be made available on a common hard media system (e.g. CD-ROM). On-demand and remote services via telecom should also be made available.
- Fully-automatic updating (i.e. the update data reaches the EDCIS directly without any human intervention) may exist. To ensure the integrity of the broadcast update, effective safe transmission mechanisms and/or error detection methods should be employed.
- Updating of the ENC occurs at the ECDIS equipment, and should be accomplished in a user-friendly way by the mariner without the need for assistance of the distributor or manufacturer.
- It is recommended that all ENC data (New ENC, New Editions, Updates and Re-issues) is distributed through a Regional ENC Co-ordinating Centre (RENC).
- It is the responsibility of the RENC to establish a distribution network for ENC data. The RENC and its distributors are entities of the distribution system.
- The supply of data through RENCs reduces the overall cost of ENCs by centralising the distribution of the data, thus avoiding the need for each individual HO to invest in developing their own service and distribution network, thus simplifying the purchasing of ENC data. RENCs also act as „one stop shops".
- RENCs can also ensure that data is of uniform quality (in terms of its validation against S-58) and that there are no gaps, or overlaps or inconsistencies between adjacent cells.
- RENCs help promote the production of ENCs around the world, and thus help to ensure that developments in electronic charting are coordinated and meet the requirements of the market.

STEP 2 – Sign Agreement

- Whatever distribution mechanism is adopted, where an outside organisation such as a RENC is involved, the rights and responsibilities of each partner should be detailed in a signed agreement.

STEP 3 – Distribution Format

- Distribution through a RENC is not mandatory. If data is not distributed through a RENC, a security system should be applied to protect the integrity of the data, prove authenticity, and prevent unauthorized copying. Reference should be made to S-63 (IHO Data Protection Scheme).

- In addition to standard S-57 (either encrypted or unencrypted) ENCs can also be distributed directly in the SENC format proprietary to an ECDIS manufacturer.

10.6: Concepts of Geographic Feature Representation

The information content of the geographic items contained in the chart or data base, respectively, has to be defined somewhere in order for a chart/data base to be usable. The place where these definitions can be found is generically referred to as 'data dictionary'.

❖ Cartographic Presentation

In cartography, geo-information is traditionally 'stored' on the chart itself (or, to be more precise, on the original of a chart). This means that geo-data were simultaneously recorded and displayed using cartographic symbology (e.g. point represented by an icon, a special type of line, area symbols, and lettering). Under international agreement between members of the International Hydrographic Organization (IHO), most of the symbology used for official paper nautical charts are based on what is contained in the International Chart 1, actually a reference book, that is published by the Hydrographic Offices as a legend to their charts. This is the 'data dictionary' of the traditional chart.

With the advent of the new computer-assisted techniques in cartography, suitable digital equivalents of cartographic symbology – feature codes – have been created to represent the same geo-information. A chart digitized in such a way generates a near-perfect image of a paper chart on the screen. However, this offers only a small advantage when compared to a raster chart. For example a symbol of a buoy with a specific topmark is stored in the database, and its meaning can be queried by computer cursor ('mouse click'). The user can then explicitly display the meaning of the top mark symbol in clear text by accessing the legend stored in the digital database (e.g. a cardinal north buoy). However, the color of the buoy and the possible light characteristics can be displayed only as abbreviated descriptions near the buoy symbol, since they usually cannot be inferred from the graphic symbol itself.

This method of digitization is referred to as 'graphic feature-oriented', or graphics-oriented for short, since it is based on the symbols and descriptions of the chart (i.e. its graphic features). When using graphics-oriented data, it is only possible to convey the information in the same manner as it is contained on a conventional paper chart (i.e. graphic symbology). Because feature information is represented by symbology, there are some limitations. For instance, it is difficult to use symbols to represent area characteristics.

❖ Object-based Data

To overcome the limitations of using paper chart symbology as the information carrier, other methods have been devised by which information elements can be captured and stored. It is possible to produce and use digital data that have greater capability than that of the traditional paper chart. To do so, requires a different approach: object feature-based data, or object-based data for short.

To produce object-based data, the sequence of events is turned around. The geo-information of the area to be captured are first identified and classified according to a standardized catalogue of feature objects and then stored. Using this digital data, appropriate chart graphics are generated in a quasi-automatic way. This principle is the basis of the modern Geographic Information System (GIS) in which specifically-developed database procedures are used to produce spatially-referenced data. When using an object-based approach, not only are the chart graphics and their legends available to the user, there is also the capability to convey real information in a much more detailed and structured way. This has significant advantages over the traditional paper chart. Using object-based data, you move from simple chart image to an interactive information system. It is the ‘information’ aspect of object-based data that makes the system so powerful.

❖ Objects as Constituents of Information

Based on minimum performance requirements for ECDIS, fundamentally different constituents are needed to represent the chart contents. The IMO Performance Standards for ECDIS [IMO ECDIS, 1995] specify that ECDIS recognizes automatically the ‘areas for which special conditions exist’, and that according to the type of the area, is capable of generating appropriate warnings or advice. For instance, Appendix 4 to the Performance Standards lists traffic separation zones, prohibited areas, and protected areas that must be shown and capable of generating an indication or alarm when used in ECDIS. This is a performance requirement that neither raster chart data nor graphics-oriented data can achieve.

❖ ECDIS Recognizes Area Characteristics Automatically

According to the ECDIS Performance Standards, ECDIS must recognize characteristics of 30 types of areas. However, it is not enough to define these by only using symbology (e.g. by a colored dotted line or other special form of a boundary line, or by description). Rather, ECDIS must be able to determine if the own-ship coordinates are lying within an area polygon that can be, if necessary, interrogated to find out what are the area characteristics (i.e. attributes). In addition to these 29 special areas (e.g. restricted or prohibited) there are other critical areas over which the ship sails. One of the more important is the area between two adjacent contour lines, e.g. 5m and 10m.

The characteristic information for this depth area is that this is an area where the water depth is between 5 and 10 meters. In order to define such an area, it must be stored in the database in the form of an object geometrically defined by a closed polygon (and not simply as two separate contour lines). ECDIS software can then locate any point inside the polygon, and compare it with the known draught of a ship, and automatically recognize if there exists a danger of grounding. Using the full power of ECDIS, this indication or alarm will be sounded well before the ship may enter shallow water. The ECDIS must also be able to verify that there are no dangerous conditions for a vessel in a given area, or on the planned or current course.

❖ Description of the Sea Area Through Objects

Using an electronic chart database, an electronic chart system must display the relevant characteristics of each position within the charted area, as long as they are of navigational interest. To accomplish this, the entire area must be completely covered by area objects which have specific characteristics ('skin-of-the-earth-objects'). It will be extremely rare for the coordinates of a ship's position to fall on a contour line, to say nothing about a point object. A database consisting only of contour lines, boundary lines and other linear features as well as of the buoy symbols contains almost entirely empty space to which no characteristics can be allocated. Instead, a systematic, navigation-oriented, area-based description of the charted area is required. This leads to the concept of hydrographic objects being spatial items that have a specific meaning. In describing the charted area, it is these objects that become the elementary building blocks of the electronic navigational chart.

CH. 11: CHART QUALITY AND ACCURACY

11.1: Quality of the Hydrographic Data

An Electronic Chart System (ECS) is an auxiliary navigation aid, while an ECDIS is a navigational system. Obviously, the reliability of the data – including how complete (e.g. no omissions), how accurate, and how current (e.g. up-to-date) – can have a significant impact on the safety provided by the overall system. This is valid more for nautical charts than for land maps, since charts describe the underwater regions that are usually hidden from view. While the appearance of the graphics and the ability to properly interpret the information are important ergonomic considerations, it is the quality of the data that is of primary importance in terms of navigation safety.

The quality of the data used in an electronic chart depends on several factors:

- The detail and accuracy of the hydrographic survey data;
- Source(s) used for data production;
- Frequency of updating the database;
- Quality assurance procedures applied during production.

➢ **Hydrographic Source Information**

Hydrographic Offices – the source of official chart data

All information associated with either paper and electronic charts is initially collected or even produced by, or under the authority of, a national Hydrographic Office (HO).
It is the responsibility of a HO to conduct hydrographic surveys in national waters to ensure safety of navigation. This includes measuring the water depth wherever navigation takes place, and to investigate the area for any underwater obstacles (wrecks, rocks, reefs, etc.). in addition, a HO also compiles information about aids-to-navigation, traffic regulations issued by the relevant maritime authorities, reporting requirements, vessel traffic systems (VTS), pilot stations, coastal radio station, etc. This information is then provided on charts or issued in various complementary publications such as Light Lists, Sailing Directions and Lists of Radio Signals. Any changes are published regularly in the Notices-to-Mariners (NtM). These publications

are a mandatory carriage requirement for all vessels subject to the regulation in the SOLAS Convention (IMO SOLAS V, 2000).

- **Hydrographic Surveying**

The world's Oceans: still not fully explored
Over 70% of the Earth's surface is covered by water. However, despite great advances in survey technology and remote sensing techniques, this area cannot be easily mapped and remains the largest unexplored region in the world.
Individual nations are responsible for conducting hydrographic surveys in the area consisting of the coastal strip of the territorial waters (normally 12nm from the coastline) and of the Exclusive Economic Zone (EEZ) reaching up to 200nm from the coast. The actual borders of these regions are determined in accordance with the UN Convention on the Law of the Sea (UNCLOS). For instance, Germany is responsible for a relatively small sea area of 57,000 km². However, for countries like USA, Australia, and Indonesia, with sea areas of 6 million km² or more, it is almost impossible to meet the requirements of accurate and up-to-date surveys for the entire area. In most cases, hydrographic surveys are primarily conducted in areas that are important in terms of safety of navigation. Outside these areas, charts may be based on survey data from many years ago.
And while most developed coastal nations have a hydrographic office (or service), there are many regions of the world where this is not the case. This situation is particularly problematic in Africa, where there are only a few active hydrographic services such as along the Mediterranean coast and in South Africa. As a result, the information presented on many charts of the African coastal waters is unreliable. For many regions, safe navigation in confined water is only possible with the help of local pilots. Due to the limited number of aids-to-navigation, sailing often occurs only during daylight periods.

Continuously changing sea-bottom topography
Problem areas exist even along short coastlines of highly-developed countries. For instance, in Germany strong currents in the southern German Bight of the North Sea and in some regions of the Baltic cause continuous changes of the sandy bottom. In some cases, these changes cannot be fully monitored by periodic surveys. For example, the 'Medemrinne', a secondary faiway in the Elbe estuary – the Elbe leading from the North Sea to the biggest German port (Hamburg) – has shifted over 800m to the north during only five years, changing the depths in some places by up to 10 meters. Many small North Sea ports also cope with severe sand shoaling of their entrance after every storm. It is not always possible to maintain up-to-date surveys in such areas. A paper chart can only provide suitable 'advice' on the situation. Control soundings are conducted at the entrance to several important North Sea ports every month. In other areas these surveys must be conducted more than once a year. Naturally, regular updating of the database for the electronic charts is an imperative in such shallow areas.

Warning: No electronic chart can compensate for survey deficiencies
It cannot be stressed enough, that in problematic areas the hydrographic information shown on the best electronic chart system (ECDIS) may be no better than which can

be obtained from a paper chart. It would be imprudent for a Mariner to totally rely on a computer-based system for navigation in these areas. It is not the computer that is the problem: it is the quality of the available data. If the electronic chart data is based on surveys that are out-of-date or of questionable accuracy, then the user should be warned.

- **The Need for Frequent Updating**

Every chart becomes out-of –date if it is not periodically corrected (i.e. updated). For instance, traffic regulations may be altered, buoys changed or moved, light characteristics changed, or new surveys may indicate where water depths are shallower. The changes for the paper charts are announced in the weekly Notices-to-Mariners (NtM) of the national hydrographic offices concerned. If the changes are extensive, a new edition of a chart is usually issued. It is regulatory requirement that commercial vessels keep their chart and other navigational publications up-to-date.
Electronic chart data should be maintained in the same manner as the paper charts and also be regularly updated. For ENC data, an official updating service exists. For raster data, the UK Admiralty Raster Chart Service (ARCS) and other official raster charts published by national hydrographic offices such as the US National Oceanographic and Atmospheric Administration (NOAA) also offer an updating service.

- **Quality Control and Assurance**

Production and maintenance of a digital database for electronic charts – especially for vector databases – demand a high level of quality control and assurance. The database may contain information containing an obvious error that can be immediately detected when displayed as an electronic chart image (e.g. a buoy incorrectly positioned of shore). However, there can be circumstances where the presence or absence of critical information may not be so obvious. For example, the computer software of the electronic chart system may not be able to recognize a prohibited zone if the relevant attribute was incorrect. This would occur even if the description ‘prohibited area’ was stored as a text line and displayed on the screen. In such a case, a required indication or alarm function cannot be activated since the software does not ‘understand’ the text. Under normal circumstances, the user would not notice this fault. The effects of the data error (omission) would only be noticed if an accident occurred.

This example should convey the impression of the demands being put on the producers of the electronic chart data. This is especially important to the hydrographic offices which produce official ENC data to be used in ECDIS in order to satisfy the requirement of charts. The IHO specifications and standards specify that the hydrographic offices must employ recognized quality control and assurance procedures for the production and maintenance of ENC data. Several HOs are operating already certified quality management systems. Other HOs are currently also working on implementing an ISO-compliant quality management system (QMS).

11.2: Problems in ECDIS Associated with Variant Datum

DATUM – is a point, line or surface from which all measurements either on the map or on the Earth may be referenced.

❖ **Datum (geodetic)**

A set of parameters specifying the reference surface or the reference coordinate system used for geodetic control in the calculation of coordinates of points on the earth. Commonly datum is defined as horizontal and vertical datum separately.
For a local geodetic datum the reference surface is defined by five parameters: the latitude and longitude of an initial point, the azimuth of a line from this point, and the parameters of the reference spheroid.

Absolute datum specify the initial point of the reference ellipsoid to be (ideally) located at the earth's centre of mass. For modern reference systems using datum information given by satellites additional parameters are defined, e.g. gravity models.

❖ **Datum (vertical)**

Any level surface (e.g. sea mean sea level) taken as a surface of reference from which to reckon elevations.

HORIZONTAL DATUM

The methods of determining the position in navigation have become more and more accurate. Up until the 1970s, celestial navigation was used to obtain a position fix to within 1nm. In coastal regions, radio navigation systems such as Decca were accurate to about 200m. Today, with GPS, positioning accuracy of better than 20m can be obtained. When using specially designed GPS receivers for survey operations, a positional accuracy of the order of centimeters or even millimeters can be reached. While not required for shipboard navigation, this accuracy is sufficient to measure the relative movement of continental land masses.

➢ **The Local Datum**

The geodesists must be able to relate their measurements (distance, heights) to some system of coordinates, so the location could be entered on a map or chart at the correct position. In the past, when a universal Earth ellipsoid had not been yet known, geodesists developed various ellipsoids that best represented the local surface of the gravitational potential. The dimensions of such ellipsoid were determined so that the plumb line (dependent on gravity) coincided with the ellipsoid normal line (perpendicular to the tangential of the ellipsoid) at a fixed location. Longitude and latitude were then given in relation to the ellipsoid, and the

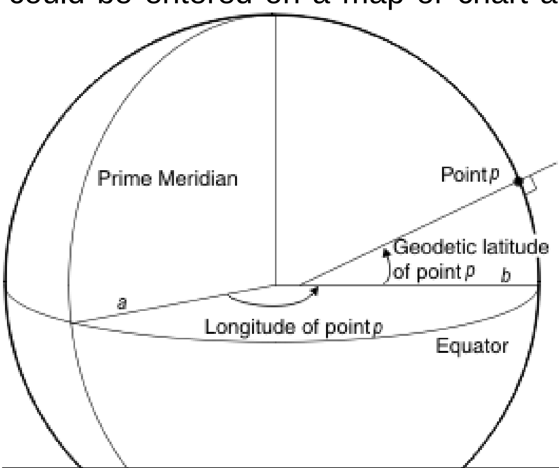


Fig. 11.1: Geodetic Latitude and Longitude of an Ellipsoid

heights were determined in relation to the ellipsoid surface.
A reference system (often called a geodetic datum) is nowadays defined using two fixed terms

- The choice of a suitable ellipsoid which is determined by specifying the large half-axis and the flattening;
- Connecting the center point of an ellipsoid in relation to the fixed center point of the Earth.

Over 100 Datum World-Wide

There are almost as many horizontal datums as there are countries, well over 100 [NIMA 1997]. Navigational charts alone use over 60 various datum world-wide, and in many cases the reference systems cannot be reconstructed. That was not important in the old-type navigation where position finding at sea was so inaccurate that its error exceeded the datum shifts.
Only when the new land-based radio positioning methods (e.g. Decca) became first used for navigation that the problem started arising. It was important that the charts were on the same datum as the geodetic coordinates of the land-based transmission chains. At first, the land surveys remained referenced to their own national datum, but comprehensive regional reference systems had to be defines for the air and sea traffic, e.g. the 'European Datum 1950 (ED50)', which is still the datum for many European charts.

WGS-84 and the Difference with Local Datum

With development of the satellite based position-finding systems like today's Global Positioning System (GPS) it became vital that an appropriate global reference system be defined. This is the World Geodetic System 84 (WGS-84), to which all the positions established with the GPS are related. Another global reference system has been defined for the Russian equivalent of GPS, the Global Navigation Satellite System GLONASS: the PE90 (identical to PZ90) which deviates however only by a few meters from the WGS-84.

It is not customary to use a local datum outside the area for which it was defined. The reverse comparison allows us to see how big the difference can be within the area of local definition between the results from GPS using WGS-84 and those based on a local datum. It is no wonder then, that with the increasing use of GPS, there were more and more complaints about allegedly 'completely incorrect charts'. In reality, the users are often uninformed of the concept of geodetic datum; hence they may be not aware of the datum of their current charts, and that it may be not WGS-84. These problems gradually disappear with more and more paper charts having been transformed to WGS84. However, there are still areas in the world where charts are based on very old surveys for which no relationship to WGS84 exists. In general, it is usually possible to convert one reference system to another. In this regard a manual on transformation parameters has been published by National Geospatial Intelligence Agency (NGA) for this purpose. It is possible to select a preferred reference system in most of the GPS receivers, the conversion follows then automatically.

When using charts and GPS together, it is always necessary to ascertain the datum of the chart and then to set the GPS receiver accordingly; this is also valid for the electronic charts, when they are not uniformly related to WGS84. However, the ECDIS PS requires the chart data to be in WGS84. When using ECS it is important to examine the chart to ensure that the data is in WGS84 and not digitized from a paper chart based on a local datum.

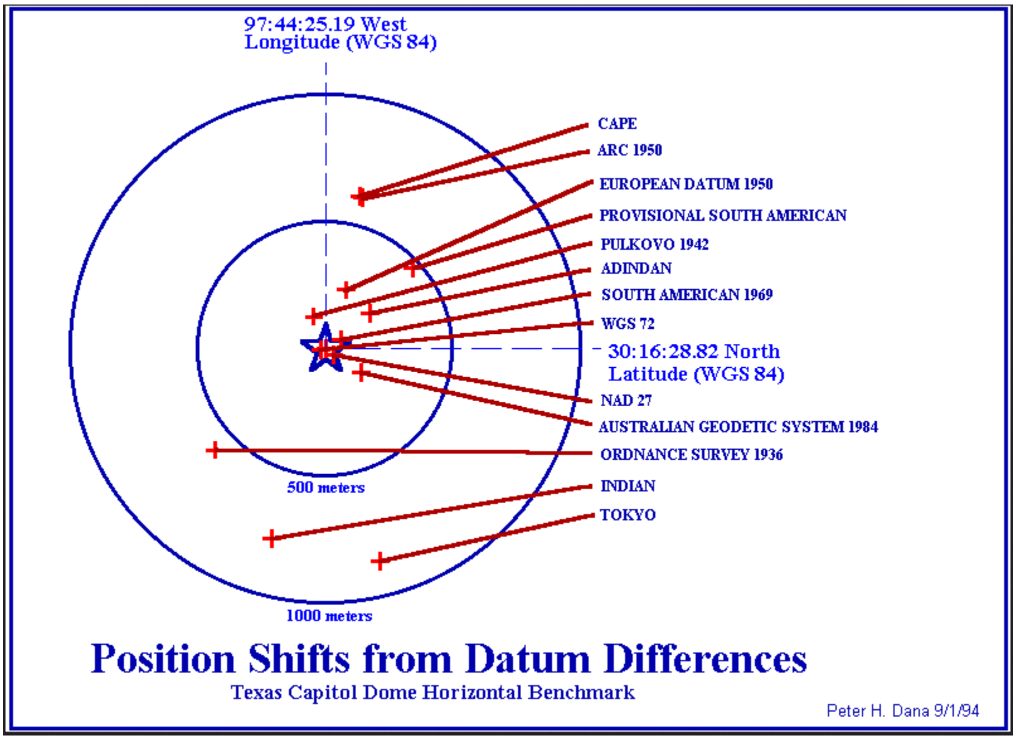


Fig. 11.2: Position Shifts from Datum Differences systems in comparison with WGS-84 based from the location of Austin, Texas, USA.

- **The Datum is Not Defined in Many Areas**

In such areas (e.g. in the Caribbean Sea), it is often impossible to convert the datum to WGS-84 precisely, because the local datum is not perfectly defined or is impossible to reconstruct. One must reckon here with a chart dependent positional error that can be of several hundreds of meters. In this situation, the GPS position is correct, but the chart contents are shifted from WGS-84 by an unknown and spatially variable amount.

Chart Datum, the Vertical Reference Level

As if it were not enough to be confused by all the different horizontal datums, one must unfortunately also come to terms with the vertical datums. In this case, we are dealing with the vertical reference system to which all depths shown on the charts are related – the chart datum which is normally a low water level. This is an important issue in areas with a perceptible tidal range (i.e. in the great majority of navigable waters). In non-tidal such as the Great Lakes of North America or the Baltic Sea, Mean Sea Level (MSL) is used as a vertical datum.

- **Depth Related to the Chart Datum are Minimum Depths (almost always)**

The purpose of providing the vertical reference of depth to chart datum is to show the minimum depths to be expected. It is the depth below which the water level is rarely

likely to fall, thus providing a safety margin for the Navigator. Tidal range is usually the main determinant of the chart datum. However, spatially it is highly variable and can vary from near zero in the vicinity of so-called amphidromic points up to 14 meters in Nova Scotia and the British and French coast of the English Channel. In addition, the tidal range varies from springs (the period of highest range) to neaps in a roughly two-weekly cycle. It would be not enough to subtract a spatially constant value from the measured depth. Chart datum therefore is defined as a surface which roughly corresponds with the lowest low water at every location and which lies at a spatially variable distance below the MSL depending on the tidal range
All depths shown on charts are reduced to the chart datum. An area with little water or even with negative depths (as happens in the intertidal zones which dry out at low water) can be navigable at high water, depending on the ship's draught.

➢ **Wind Effects Can Lower the Water Depth Below the Chart Datum**

The water level in shelf seas like the North Sea can depend not only on tides but also on wind strength and direction as well as barometric pressure distribution. The purpose of the chart datum is fulfilled here only conditionally. In areas of high water level variability caused by the strong meteorological influences the Mariner must reckon with depths occasionally shallower than shown on the chart. For instance, during a strong and prolonged southeast wind in the German Bight, the water level can fall two meters below the depth indicated on the chart. In this situation, the water is actually below the vertical chart datum because the wind simply pushes the water out of this large shallow area.

➢ **Vertical Datum also has Many Definition**

Unfortunately, no definition of uniform vertical chart datum is applied throughout the world although recently the IHO has recommended the use of Lowest Astronomical Tide (LAT). For just the North Sea, there are four different vertical datums in use. The differences can be significant and can reach 1 meter. For instance, Germany uses the Mean Low Water Springs (MLWS) which in German Bight is approximately half a meter above the datum used in English and French waters which is the Lowest Astronomical Tide (LAT), the lowest possible astronomical low water.

The effect of using various chart datums is that the depth contour lines for different national HO charts (e.g. German-Dutch border) do not meet directly, and show a so-called 'datum jump'. Accordingly, this can happen also with the electronic charts that are based on different chart datums that may be apparent in a lack of precise continuity of the depth colors. As noted above, it has now been internationally agreed that Lowest Astronomical Tide (LAT) should be the uniform chart datum and these troublesome discrepancies will eventually belong to the past.

➢ **Vertical Reference for Inland Waterways**

Inland waterways are usually located along rivers and therefore follow the gently sloping land surface from their mountainous origins down to the sea. Referencing the waterlevel of a river to some sea surface would not make any sense. On the other hand, water depths are highly time-dependent, varying with the uptake of rain (or melting snow) corresponding to the weather situation. Additionally, water depths are critical parameters for navigation on these mostly very confines, narrow waterways, and they are decisive factors for allowed draught and the cargo the inland vessels are allowed to carry. Therefore, getting depth information is of high interest for inland waterway navigation, and facilitating this constitutes one of the most useful features of an inland ECDIS.

The issue of the reference level for depth information along inland waterways can best be illustrated by considering the source of all water level measurements: water level gauges situated along the river, measuring the water depth referred to a local reference height defined individually for each gauge. A normal water depth can be determined for each gauge position, and the time-varying deviation of the water level from this normal depth can be continuously recorded. A depth model of the river bottom can be determined by hydrographic soundings, corrected by the deviation of water level from its normal level. This is the normal depth which is contained in the inland ECDIS' database.
The actual water depth along the river can be calculated from the depth at a position contained in the database by adding the actually measured difference between the water level and the normal value at the gauge, which can be, e.g., broadcast to the Navigator. It is important, though, that only information from the nearest gauge station is used.

11.3: Data Quality

It must never be forgotten that the data contained with any chart, electronic or paper, may be inaccurate for many reasons, including:

- **i.** There may have been physical changes to the charted situation since the area was last surveyed, such as those due to silting, dredging, recent wrecks and coastal reconstruction.
- **ii.** There may have been changes to the position of navigational aids, either through intentional re-planning or through accidental reasons, such as the dragging of a buoy.
- **iii.** The survey may be inaccurate. In particular, older surveys used more primitive techniques than available today. Charts may therefore have been based on surveys using inferior position fixing techniques to local datums that, in addition, may not be able to be accurately referenced to WGS84.
- **iv.** The original survey may have been based on an insufficient number of spot measurements. For this reason the topology of the seabed may vary considerably between the surveyed points. This fact contributed to the grounding of the *Queen Elizabeth 2*, off the coast of Martha's Vineyard in 1992.
- **v.** The chart may contain a compilation error that has not been picked up by the quality assurance process. There are still differences in overall quality between products from different hydrographic offices.
- **vi.** The chart may not be suitable to be used for the purpose in hand, for example, the chart is not of sufficient scale for the accuracy of navigation that is being attempted.

And users must always ensure that charts are kept fully up-to-date; otherwise, it substantially increases the probability of encountering a problem.

On RCDS and paper charts the Source Data Diagram within the Notes should be consulted to establish survey dates. Often other data to help the users establish an appropriate degree of confidence is also given. On ENCs, the IHO is encouraging hydrographic offices always to include Zone of Confidence data.

Zone of Confidence

There is an important object attribute in ECDIS known as the 'Category of Zone of Confidence in Data'. This has the attribute name CATZOC in S-57 but is often further abbreviated to ZOC in documents. The ZOC category allocated indicates that particular ENC data meets minimum criteria for position and depth accuracy. It can be looked upon as the survey accuracy. There are six category levels – A1, A2, B, C, D and unclassified (data not assessed).

It is important that users know the ZOC for the areas of navigation covered by the voyage as it clearly affects both voyage planning and voyage monitoring activities and decisions. Unfortunately, not all ENCs have ZOCs assigned to the data but the IHO has asked for this situation to be rectified as soon as practicable. A number of groundings have occurred when ZOC is easy to access with a dedicated menu command. On others, it has to be accessed by other means. This can use the Pick Report in the area of interest and scrolling down to the CATZOC data. The user can also set the Display Detail to All Other Information to, for instance, the Standard Display. This displays the category data by a star rating. Five stars correspond to category A1 and one star to category D.

The Pick Report method is perhaps the least useful method to ascertain the ZOC level, even if it is quick to implement, as it will not give the boundaries where the category changes. Also, on some systems the information is not included within the report. Use of All Other Information will make the display very cluttered but on many systems this is the easiest method of showing the data. Because of the clutter generated, the display could not be left on the All Other Information setting.

There is no doubt that ZOC is not a well implemented feature on most ECDIS equipment, despite its importance. The situation is not helped by the lack of mandatory requirements for easy display of ZOC data. However, it is realized that it should be better configured and ongoing work at the IHO should resolve the matter. Unfortunately, in general, existing equipment will remain with this feature being relatively user unfriendly well into the future.

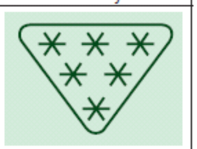
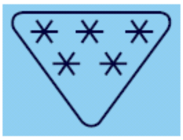
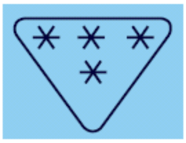
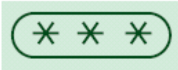
1	2	3	4	5	6
ZOC 1	Position Accuracy	Depth Accuracy	Seafloor Coverage	Typical Survey Characteristics	CATZOC Symbol
A1	± 5 m + 5% depth	= 0.50 + 1%d Depth (m) / Accuracy (m) 10 / ± 0.6 30 / ± 0.8 100 / ± 1.5 1000 / ± 10.5	Full area search undertaken. Significant seafloor features detected and depths measured.	Controlled, systematic survey high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.	
A2	± 20 m	= 1.00 + 2%d Depth (m) / Accuracy (m) 10 / ± 1.2 30 / ± 1.6 100 / ± 3.0 1000 / ± 21.0	Full area search undertaken. Significant seafloor features detected and depths measured.	Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder and a sonar or mechanical sweep system.	
B	± 50 m	= 1.00 + 2%d Depth (m) / Accuracy (m) 10 / ± 1.2 30 / ± 1.6 100 / ± 3.0 1000 / ± 21.0	Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOC A2, using a modern survey echosounder, but no sonar or mechanical sweep system.	
C	± 500 m	= 2.00 + 5%d Depth (m) / Accuracy (m) 10 / ± 2.5 30 / ± 3.5 100 / ± 7.0 1000 / ± 52.0	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.	
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				

Fig. 11.3: Category of Zone of Confidence Definitions with corresponding ECDIS symbol

Data Chart Accuracy

1. As in the case of any shipboard gear, the user must be aware of the capabilities and limitations of digital chars. The mariner should understand that nautical chart data displayed possess inherent accuracy limitations. Because digital charts are necessarily based primarily on paper charts, many of these limitations have migrated from the paper chart into the electronic chart. Electronic chart accuracy is, for most part, dependent on the accuracy of the features being displayed and manipulated. While some ECDIS and ECS have the capability to use large-scale data produced from recent hydrographic survey operations (e.g. dredged channel limits or pier/terminal facilities) most raster and vector-based electronic chart data are derived from existing paper charts.

2. In the past positioning methods, an order of magnitude less accurate than the horizontal accuracy of survey information was portrayed on the chart. For example, a three-line fix that results in an equilateral triangle sides two millimeters in length at a scale of 1:20,000 represents a triangle with 40-meter sides in real-world coordinates.

3. A potential source of error is related to the system configuration, rather than the accuracy of electronic chart data being used. All ECDISs and most ENCs enable the user to input the vessel's dimensions and GPS antenna location. On larger vessels, the relative position of the antenna aboard the ship can be a source of error when viewing the "own-ship" icon next to a pier or wharf. In U.S. waters, the Coast Guard's DGPS provides a horizontal accuracy of +/-10 meters (95 percent). However, with selected availability off, even the most basic GPS receiver in a non-differential mode

may be capable of providing better than 10 meter horizontal accuracy. In actual operation, accuracies of 3-5 meters are being achieved. As a result, some mariners have reported that when using an electronic chart while moored alongside a pier, the vessel icon plots on top of the pier or out in the terminal.

4. The overall horizontal accuracy of data portrayed on paper charts is a combination of the accuracy of the underlying source data and the accuracy of the chart compilation process. Most paper charts are generalized composite documents compiled from survey data that have been collected by various sources over a long period of time. A given chart might encompass one area that is based on a lead line and sextant hydrographic survey conducted in 1890, while another area of the same chart might have been surveyed in the year 2000 with a full-coverage shallow-water multibeam system. In the U.S., agencies have been typically used the most accurate hydrographic survey instrumentation available at the time of the survey.

5. While survey positioning methods have changed over the years, standards have generally been such that surveys were conducted with a positioning accuracy of better than 0.75 millimeters at the scale of the chart. Therefore, on a 1:20 000-scale chart, the survey data was required to be accurate to 15 meters (Refer to Figure 11.3 Category of Zone of Confidence, as shown above).

LESSON 2: WATCHSTANDING WITH ECDIS

CH. 12: SENSORS

A stand-alone electronic chart may be able to serve as a useful and attractive graphic display showing valuable (chart) information to the Mariner. However, to achieve its full potential, it needs to be the central point for instrument connection and an essential element of an integrated navigation system.

And to continuously display the position in real-time mode connection of position, input sensor is one of the requirements. To display the position of the vessel, the accuracy of the position at all times is really important. DGPS, GPS, or LORAN inputs may be used as primary or secondary means of position fixing. The accuracy of the position depends upon the accuracy of the other components which may not be forming the part of ECDIS but may be the position fixing system itself. For example, the GPS fix quality may get affected by the geometry of the satellites, HDOP (Horizontal Dilution of Precision).

The system’s unique ability to combine the radar image with the chart image by a single action gives an immediate and constant confirmation of the navigators’ decisions. The information about other ships provided by AIS, which will be implemented in accordance with the new SOLAS Chapter V, will most naturally be displayed on the ECDIS display to further increase the knowledge about other ships in the area.

During ocean passage, the ability to combine forecasts on weather, sea and swell with the planned route allows for onsite weather routing quickly and easily resulting in fuel savings. The subsequent amendments to the route planning are carried out in a matter of minutes. The ECDIS software takes care of checking for dangers to navigation automatically, provided a vector chart is used through the archipelagos and the narrow channels and inlets.

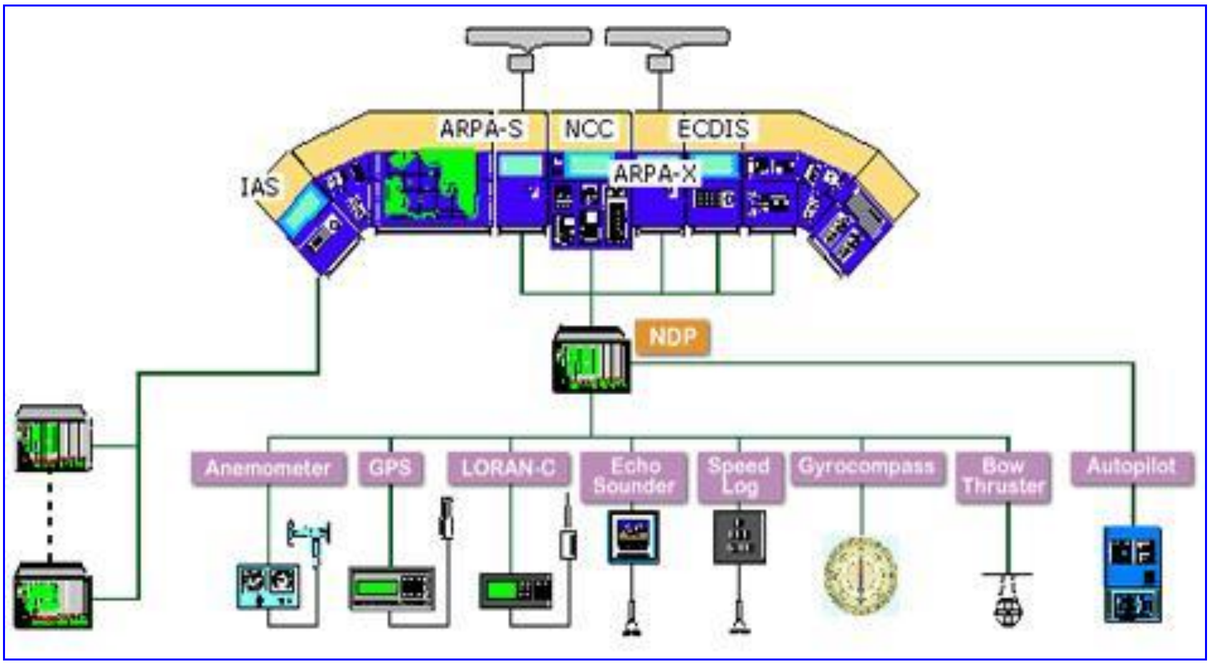


Figure12.1: ECDIS configuration

12.1.1: Position Sensor

ECDIS should be connected to systems providing continuous position-finding, information either with DGPS, DPS or Loran-C, which may be used as primary or secondary means of position fixing.

The accuracy of the position fixing depends upon the accuracy of other components, which may not be a part of ECDIS but of the position fixing system itself. For example, the GPS fix accuracy may be affected by the geometry of the satellite, HDOP.

Hence, the accuracy of the fix should be expressed in probability terms only “the accuracy is 100m (95%)” means that the actual position of the vessel in 5% cases is worse than 100m.

Accuracy of the position may arise due to the use of different horizontal datum between the ECDIS and the other position fixing instruments. There are many known datum used worldwide, where WGS84 is used by the ENC as specified by the IMO.

If the ECDIS and other systems are used on different datum, there may be a large inaccuracy of position between the two and inaccuracy can be relatively large depending upon which datum is used. For example, a GPS may be able to fix a position within a range of error of about 20m, whereas the difference in position between WGS and others can be beyond 1000m.

Effects of inaccurate position input:

a. If the primary position fixing fails or becomes unreliable, system must switch over to secondary positioning system and user must know that quality or the accuracy of the position might have degraded. For example, the quality when the primary sensor fails, e.g. after an automatic switch over from DGPS to GPS the accuracy is 100m instead of 10m.
b. Hence, use of the second position-fixing system (Loran C, Radar, DR) should be used for position monitoring and the errors associated with this system should be kept in mind.

Position Page: *(see Chapter 7.3)*

Risks and Effects of Inaccurate Position Determination

Failure and reduced reliability of GPS/DGPS, in particular, could occur in several ways:

- Loss of view of individual GPS satellites caused by ship's superstructure; multiple signal reflections ('multi-path'); radio interference from other shipboard systems (e.g. INMARSAT communication, VHF);
- Loss of differential broadcast corrections (DGPS signal) due to weather fronts, lightning bursts, and other meteorological disturbances.

A defective or inaccurate position fixing system leads to a false position display of 'own ship' on the electronic chart. This may seriously endanger the ship's safety. With automatic position fixing and display (like by GPS and ECDIS), the Watch Officer might become too complacent and take the displayed position for granted. It is human nature to over-rely on a system that requires little or no action on the part of the user. The stranding of MS 'Royal Majesty' caused by a broken antenna cable could have easily been avoided. In contrast, a Mariner plotting own ship's position on a paper chart would have to construct the lines of position and/or double check the manual entries.

In an ECDIS radar overlay display, an incorrect position may result in displaying radar targets in incorrect locations. However, the divergence of the displays of coastlines, reference targets etc. – originally considered as a drawback of overlay – is a powerful tool to detect positional errors.

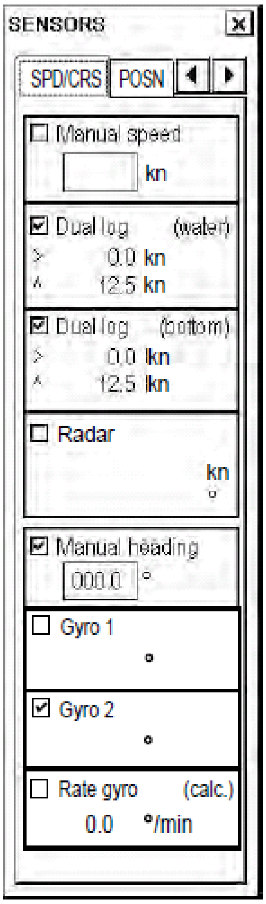
12.1.2: SPEED AND COMPASS (HEADING) SENSORS

Gyro compass and speed logs are used to provide input for course and speed input to ECDIS. Speed over-ground is used for the monitoring of vessel's position on ECDIS.

While the following must be known to the user:

a. In the automatic track control mode, the observed position is always displayed in the pre-planned track, even if the off track error is large.
b. Calculated values, such as ETA at the next way point or without point, depends on the accuracy of the sensors.
c. The displayed information must be unambiguous e.g. vector type ‘over the ground’ or ‘through the water’ depends on the type of speed and course input. Hence, user must fully understand the difference between the speed over-ground and speed through water.

Speed / Course Page:



Manual Speed – This is used only if there are no other speed or SOG sensors chosen.
Dual Log (Water) –A dual log is used as speed and course source. "(water)" is used to indicate that this information is from water track of dual log.
Dual Log (Bottom) – A dual log is used as speed and course source. "(bottom)" is used to indicate that this information is from bottom track of dual log.
Radar – If checked, radar is used as speed and course source. The following indications appear to denote source:

(bottom): Log operating in bottom tracking mode.
(water): Log operating in water tracking mode.
(posit.): Position receiver such as GPS.
(manual): Manual speed
(reftgt): Tracked Target

Manual Heading – If selected, the operator enters heading manually. And this is used only if there are no other sensors selected.
Gyro1 – Heading source is a gyrocompass. "(mag)" means the source is magnetic heading. True heading source has no indication. If the source of Gyro1 is a gyro with synchro or stepper interface, the indication "(require set)" appears when you need to set a new initial value for the gyro.
Gyro2 – True heading source has no indication. If you have both gyro1 and gyro2 selected and if their value differs more than 5°, the system generates an alert status.
Rate Gyro – Heading source is a Rate of Turn gyro. **"**(calc.)" means the rate of turn is calculated from gyro movement.

Setting Initial Value of Gyro1 – Initial setting of gyro1 is not necessary if it outputs serial data. However, if it is of synchro or stepper type, you will need to set initial gyro value. If gyro1 requires initial value, then the indication "(require set)" is displayed. Use the scrollwheel to enter initial value. After you enter a value "require set" disappears.

Course and Speed Sensors Accuracy

Ship's compass and speed log are used to determine the course and speed of own ship. Both are normally interfaced to the electronic chart. Gyro compass and Doppler log offer the highest accuracy in practical onboard operation. Gyros are required for commercial ships above certain size; Doppler logs are not, but they are installed on most modern ships.

- **Gyro Compass**

The accuracy of a Gyro compass, taking into consideration installation and speed errors, is normally about 0.5" to 1". However, this value can increase to 3" to 4" during and after maneuver due to an acceleration error.

- **Speed Log**

The accuracy of speed-over-ground measured with a bi-axial Doppler log (bottom track) is 0.2 to 1 knot in water depths between 1 and 300m (depending on the manufacturer). The accuracy of measured speed-through-water (water track) is usually lower than speed-over-ground due to the effects of turbulence created by the ship. This is especially true in shallow water.

- **Overview**

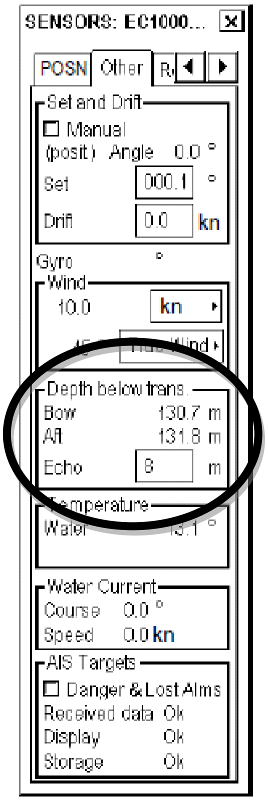
Other compasses and logs used in navigation are less accurate. For different applications, different course and speed parameters (both for own ship and for other vessels being tracked) are appropriate. ***Table 12.2 (below)*** provides an overview of the various applications, parameters and sensors that are normally used. Derivatives of satellite navigation systems play an increasing role. Despite the advent of satellite navigation and AIS, ship-bourne course and speed measuring devices (Gyro, Doppler or Electro-Magnetic log) will continue to be used because they are independent of external signals.

Parameters	Application	Sensor/source
Course and speed over ground (own ship)	Navigation with ECDIS	Bi-axial bottom track Doppler log or DGPS/GLONASS
Speed through water (own ship)	Maneuvering	Mono-axial water track Doppler log or electro-magnetic log
Heading (own ship)	Navigation, maneuvering, collision avoidance	Gyro-compass or SATNAV (2 antennas)
Rate of turn (own ship)	Maneuvering	Turn indicator or derivation from Gyro course
Course and speed over ground (other vessel)	Radar overlay in ECDIS	Own radar/ARPA; AIS/DGPS
Heading (other vessel) Rate of turn (other vessels)	Collision avoidance with ECDIS/radar overlay Collision avoidance with ECDIS/AIS overlay	AIS AIS

Table 12.2: (Possible) Sensors for course and speed measurement for different applications.

In many respects, an electronic chart is only capable of performing as well as the sensor inputs it receives. For a variety of reasons, an effective and unambiguous data management system is necessary to provide the correct inputs.

12.1.3: DEPTH SENSOR



Although a depth sensor is not a mandatory requirement as per the IMO Performance Standard, the mariner must be aware of the underlying danger of shallow water where the safety depth contour alert is based on chart datum and not with echo sounder.

DEPTH PAGE:
The depth output from a depth sensor (for example, echo sounder) is shown on the Other page in the Sensors dialog box.
The content of the Other page in the Sensor menu depends on sensors connected.
In this example there are two transducers (bow and aft) installed.

12.1.4: RADAR/ARPA SENSOR

Radar is also not a mandatory requirement as per the IMO Performance Standard which is an aid to the navigator for collision avoidance with the speed input being through water. Hence, radar overlay may create a certain conflict. But radar overlay provides an instant view and confirms the accuracy of the vessel's position as input from the other sensors i.e. if the land image of the radar video coincides with the charted details user can safely assume that the position of the vessel as displayed on the chart is accurate hence the position sensor.

Position of the vessel displayed on the chart with radar overlays may vary if the antenna position of the GPS and Radar are distance apart and not been synchronized to conning station hence antenna position off-set need to be corrected either automatically or manually.

Menu to control the input sources for ARPA tracks and radar video.

ARPA Target Sources: Select up to three sources for ARPA tracks. Lamps blink when receiving target data from the source.

Radar Video Sources: Select one of the radar sources to display radar video. The corresponding lamp blinks when receiving radar video from the source.

Message field: For showing radar video, display mode (north up/head up) for the radar source and the ECDIS unit must be the same; otherwise an alarm message is given.

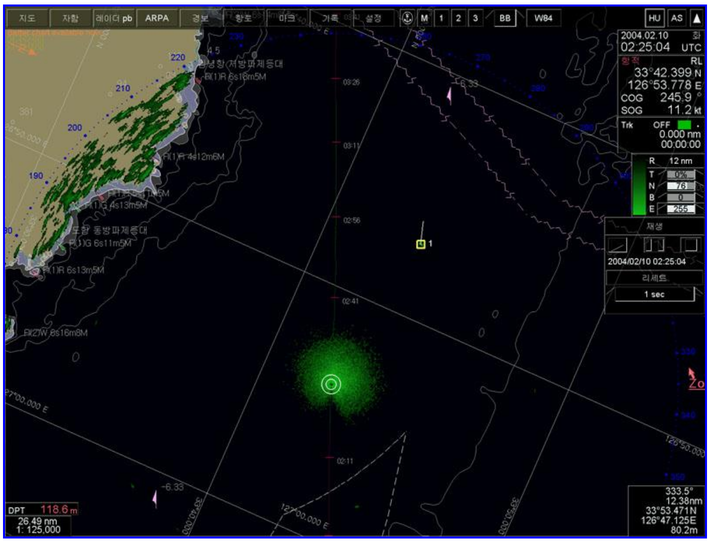


Figure12.3: ARPA tracks and RADAR video

Performance Features and Limitations

The radar image has improved considerably over the last 20 years due to a variety of factors including:

- 'daylight radar' (e.g. digital signal processing, raster-scan technology);
- Improved discrimination (small digital/bearing increment, more pixel);
- Improved clutter reduction (e.g. through scan-to-scan correlation);
- Automatic target tracking (Automatic Radar Plotting Aids; 'ARPA').

However, several shortcomings are still present:

- Limited accuracy and discrimination capabilities;
- Constrained range by such physical factors as power, radar horizon, rain, snow;
- Poorly reflective targets (e.g. small targets, wooden vessels);
- Complicated operation due to many functions with which to be familiar.

The accuracy and discrimination of radar depend on the selected range scale, pulse length, horizontal beam width, and fineness of digitization, screen resolution and operational settings (e.g. Fast Time Constant/FTC'). In short range scales (below 1.5n.m.), this can be of the order of 10 m – like ECDIS. Any distortion will result in a small shift of a radar target position in comparison with the corresponding ECDIS object.

12.1.5: AIS SENSOR

Automatic Identification System (AIS) a shipboard broadcast transponder system, operating in the VHF maritime band, today majority of commercial ships are equipped with the device that sends continuous information about the characteristics and movements of the own ship.

The introduction of such an identification system broadens the area of usage of the electronic chart, because through conveying of the actual navigational data of the vessels in the surrounding sea area can these vessels not only be shown and the numerical values of their movement parameters displayed on demand; in addition can the correlation with the radar observations be shown and the echoes from vessels securely as such be identified and allocated. Typical delays in ARPA evaluation of the radar echoes data during the maneuvers of the observed ship (change of course or speed) can be almost completely compensated through this technology. AIS technology therefore supplements effectively Radar/ARPA for collision avoidance done at the electronic chart. These advantages however, can give their full value only when the mechanism for displaying and evaluation of the AIS information is successfully harmonized with both other systems delivering local information – radar/ARPA and VTS.

Cautions and Limitations in the Use of AIS

Users of AIS should always bear in mind that information given by AIS may not give a complete picture of the shipping traffic within the vicinity. There are many reasons why the AIS may not be able to perform such feature (i.e. malfunction, being switched off, etc.).

And when AIS information is used to assist in collision avoidance decision-making, the following cautionary points should be borne in mind:

1. ECDIS with AIS function is an additional source of navigational information. It does not replace, but rather augments other navigational equipment and system such as the radar, ARPA and VTS.
2. The use of AIS in ECDIS does not exempt the OOW from complying with COLREG at all times.
3. The user should not rely on the AIS as the sole information system, but user must also make use of relevant safety information available.
4. The OOW should always be aware that other ships, in particular yachts and other leisure crafts, fishing boats might not be fitted with AIS or ECDIS
5. The OOW must always be aware that transmission of erroneous information entails a risk to other ships as well as their own. The users remain responsible for all information entered into the system as well as the information added by the sensors. This means to say that operators must check their own ship AIS information at regular intervals and whenever he suspects that something is amiss.
6. The accuracy of AIS information received is only as accurate as the information transmitted. That is information received by your unit will depend on the quality of information transmitted by each ship.

Source of AIS Target Related Alarms

The alarm ”AIS Target Overflow” warns that the maximum number of AIS targets set to display on the ECDIS has exceeded the user-specified maximum range. It is possible that some of the AIS targets are not displayed on the ECDIS.

12.1.6: WIND SENSOR

Wind Sensor Data
This menu gives the direction and strength of the wind data received from the selected wind sensor.

No **:** Depth sensor number.
Type **:** Depth sensor name and type.
Latest Update **:** Time since the last wind data was received.
Rel. Wind **:** Wind direction and speed relative to ship heading and speed.
True Wind **:** Wind direction and speed relative to north and ground.
Display Arrow **:** Select to display wind arrow in the chart. The wind arrow in the chart displays true wind.
Configure **:** Push to display the wind sensor configuration menu.

Wind sensor configuration
Menu to configure the depth sensor. It gives the status of the selected depth sensor.

No **:** Wind sensor number. If there are multiple wind sensors select one.
Type **:** Wind sensor name.
Latest Update **:** Time since the last wind data was received.
Wind Speed **:** Raw wind speed received from the sensor.
Wind Direction **:** Raw wind direction received from the sensor.
Mode **:** The data as received from the wind sensor is either:
* Relative to ship heading and speed.
* Relative to ship heading and water speed.
* Relative to ground and north. **m/s or Knots:** Select the unit for presentation in wind sensor data.

Wind Arrow Symbol Offset **:** Specifies the wind arrow's offset in millimetres, from the own ship symbol in the chart display

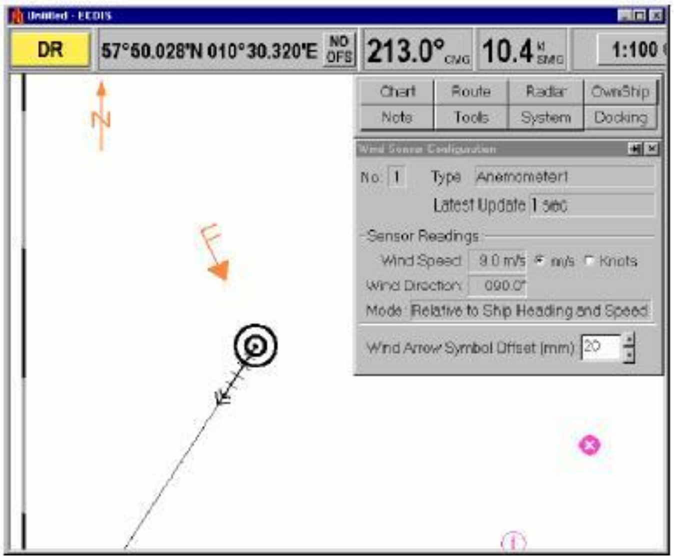


Figure12.4: Wind arrow display

12.2: ECDIS Configuration

Before understanding the operation of ECDIS, it is important to have a general idea of how it is configured on a ship. On any particular ship the details vary but an 'interconnection' diagram for a common set-up is shown in Figure 12.5.

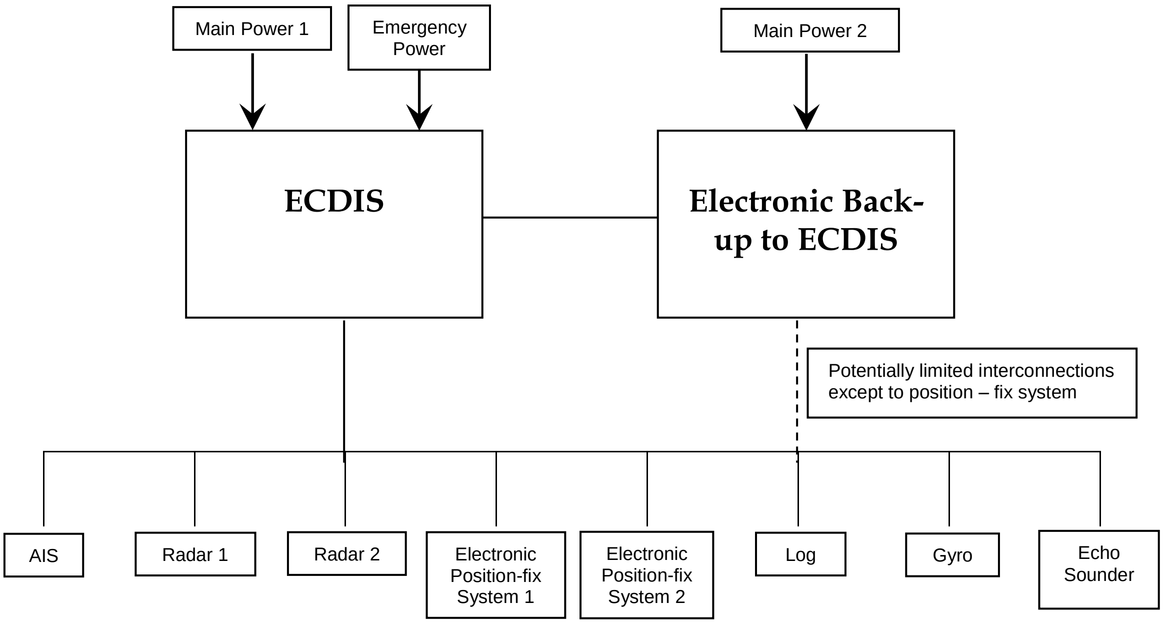


Fig. 12.5: ECDIS Configuration

There are three critical aspects:

1. The equipment is interconnected with a backed-up position fix system, such as dual GPS receivers but preferably dual multi-service receivers.
2. There is an ECDIS back-up system compliant to IMO requirements
3. The primary ECDIS is connected to the emergency power supply of the ship to ensure continued operation if the main supply fails.

Optional, but common, interconnections of the ECDIS to other equipment are as follows:

- To the gyro or magnetic compass, enabling the display of heading, also head- and course-up modes as an alternative to North-up
- To the AIS, enabling the display of AIS target positions
- To the radar, enabling TT/ARPA vectors of tracked targets to be displayed
- To the echo sounder enabling depth to be displayed
- To the speed log allowing STW to be displayed (SOG from the position fix system)

A more comprehensive setup may also include:

- A special interconnection with the radar to allow the 'raw' radar image to be displayed

- Position fix information from an INS after checks for integrity, validity and accuracy have been made, possibly by using more than one position fix system.

When using sensor information, ECDIS will take into account the different reference systems that will apply. For instance, speed from a log will be water referenced (STW), whereas speed from a positioning system such as GPS will be ground referenced (SOG). Depth from an echo sounder is normally referenced to depth under keel and is obviously very different based to the depth indicated on ECDIS. The latter is to a certain vertical reference, such as Lowest Astronomical Tide, which is most unlikely to be the actual depth under keel. Knowing the horizontal datum of the displayed chart is equally important. As already explained, ENCs are always to the WGS84 datum. RCDS and private data can be to other datums.

Compass bearings may be true or magnetic, and so it is necessary to look for the T and M suffixes respectively when displayed on ECDIS and, if necessary, compensate appropriately for magnetic variation. Target vectors, if available from the radar, may be true or relative and this must obviously be ascertained, especially if ECDIS is used to support collision avoidance decisions. However, it is emphasized that ECDIS should never be used as the primary tool for such decisions, with visual and radar displayed data providing the main support. This is because ECDIS is not designed to be a primary aid for collision avoidance, even when overlaying radar data. For instance, radar data is not permitted to obscure important chart information on an ECDIS and therefore may not appear as evident as it would be on a dedicated radar display.

Increasingly, ECDIS is implemented as a function of Multifunction Task Station (MFTS), possibly as part of an Integrated Navigation System. The functionality can be switched from ECDIS to radar and possibly other configurations. It is important, when wanting to use the equipment as an ECDIS, that it is explicitly ‘switched’ to this setting. If it is acting primarily as a radar with chart underlay, it will not operate completely to IMO requirements as an ECDIS.

12.3: LISTS OF SENSOR-RELATED ALARMS (ECDIS should generate the following alarms regardless for model and maker)

The following alerts, which are not described elsewhere, are related to sensors.
"**2055 Radar Comm. Error":** Lost connection to radar 1. As a consequence the system loses Tracked Targets and speed/course available from radar.
"**2071 Source Radar changed":** Lost connection to the radar which is the source Tracked Targets and speed/course information. Then, if other radars exist, the system selects one of them as the new source of Tracked Targets and speed/course information and the system generates alert 371.
"**4001 B-Adapter Error":** Lost connection to B-Adapter, which is an interface to various navigation sensors.
"4002 Engine Control Comm Error : Lost connection to engine control, which could be an interface to various navigation sensors.

"4005 Gyro Error": Lost connection to gyro1 sensor.
"4008 Log Error": Lost connection to log sensor.
"4009 Dual Axis Log Error": Lost connection to dual-axis log sensor.
"4010 Echo Sounder Error": Lost connection to echo sounder sensor.
"4011 Wind Sensor Error": Lost connection to wind sensor.
"4012 Position Eq Error": Lost connection to position sensor number 1.
"4018 ROT gyro error": Lost connection to ROT gyro sensor.
"4021 ARPA Radar system Error": Displayed if radar number 1 reports internal failure.
"4201 Ext. Navigation Eq. Error": Displayed if external navigation equipment number 1 reports internal failure.

CH. 13: PORTS AND DATA FEEDS

Traditionally bridge (and other) instruments have tended to be developed in isolation, with each having an individual method of measuring and displaying data. Ergonomics was a discipline for the future and each instrument had to fight for its position on the bridge. As each new instrument was added to existing bridges, they were invariably placed wherever a vacant spot existed. In time, the grouping and placement of instrument displays was given some consideration in vessels under construction. It is only relatively recently, with the widespread digitization of data that the ability to integrate and display the data has become a possibility. With the development of an international standard for data format and transmission protocols, integration is now becoming more commonplace. Whilst initially some manufacturers did integrate instruments of their own manufacture, it is now possible to integrate instruments from different manufacturers who adhere to these common standards.

13.1: Connectivity

Initially, the interfacing between different items of navigational equipment was individual to certain manufacturers. However, more open general standards have been developed. The NMEA (National Marine Electronics Association) data standard was developed in the early 1980s and is still extensively used where the data rate required is low. Most radar devices have some NMEA connection so the NMEA 0183 standard is covered here. Other interfaces still tend to be manufacturer specific.

13.1.1: NMEA 0183

NMEA 0183 is a combined electrical and data specification for communication between marine electronic devices such as echo sounder, sonars, anemometer, gyrocompass, autopilot, GPS receivers and many other types of instruments. It has been defined by, and is controlled by, the U.S.-based National Marine Electronics Association. It replaces the earlier NMEA 0180 and NMEA 0182 standards. In marine applications, it is slowly being phased out in favor of the newer NMEA 2000 standard.

The NMEA 0183 standard uses a simple ASCII, serial communications protocol that defines how data are transmitted in a "sentence" from one "talker" to multiple "listeners" at a time. Through the use of intermediate expanders, a talker can have a unidirectional conversation with a nearly unlimited number of listeners, and using multiplexers, multiple sensors can talk to a single computer port.

At the application layer, the standard also defines the contents of each sentence (message) type, so that all listeners can analyze messages accurately.

13.1.2: NMEA 2000

NMEA 2000 is a protocol used to create a network of electronic devices—chiefly marine instruments—on a boat. Various instruments that meet the NMEA 2000 standard are connected to one central cable, known as a backbone. The backbone powers each instrument and relays data among all of the instruments on the network. This allows one display unit to show many different types of information. It also allows the instruments to work together, since they share data. NMEA 2000 is meant to be "plug and play" to allow devices made by different manufacturers to talk and listen to each other.

Examples of marine electronic devices to include in a network are GPS receivers, auto pilots, wind instruments, depth sounders, navigation instruments, engine instruments, and nautical chart plotters. The interconnectivity among instruments in the network allows, for example, the GPS receiver to correct the course that the autopilot is steering.

The NMEA 2000 standard, same with NMEA 0183, was defined by, and is controlled by, the US-based National Marine Electronics Association (NMEA). Although the NMEA divulges some information regarding the standard, it claims copyright over the standard and the contents thereof are thus not publicly available. For example, the NMEA publicizes which messages exist and which fields they contain but they do not disclose how to interpret the values contained in those fields. However, enthusiasts are slowly making progress in discovering these PGN definitions. The PGN indicates which message is being sent, and thus how the data bytes should be interpreted to determine the values of the data fields that the message contains.

NMEA 2000 connects devices using Controller Area Network (CAN) technology originally developed for the auto industry. NMEA 2000 is based on the SAE J1939 high-level protocol, but defines its own messages. NMEA 2000 devices and J1939 devices can be made to co-exist on the same physical network.

NMEA 2000 (IEC 61162-3) can be considered a successor to the NMEA 0183 (IEC 61162-1) serial data bus standard. It has a significantly higher data rate (250k bits/second vs. 4800 bits/second for NMEA 0183). It uses a compact binary message format as opposed to the ASCII serial communications protocol used by NMEA 0183. Another improvement is that NMEA 2000 supports a disciplined multiple-talker, multiple-listener data network whereas NMEA 0183 requires a single-talker, multiple-listener (simplex) serial communications protocol.

13.2: Data Reference System

- **Geodetic System**

The World Geodetic System is a standard for use in cartography, geodesy, and navigation. It comprises a standard coordinate frame for the Earth, a standard spheroidal reference surface (the datum or reference ellipsoid) for raw altitude data, and a gravitational equipotential surface (the geoid) that defines the nominal sea level.

The latest revision is WGS 84 (dating from 1984 and last revised in 2004), which was valid up to about 2010. Earlier schemes included WGS 72, WGS 66, and WGS 60. WGS 84 is the reference coordinate system used by the Global Positioning System.

The coordinate origin of WGS 84 is meant to be located at the Earth's center of mass; the error is believed to be less than 2 cm.

The WGS 84 meridian of zero longitude is the IERS Reference Meridian, 5.31 arc seconds or 102.5 metres (336.3 ft) east of the Greenwich meridian at the latitude of the Royal Observatory.

Presently WGS 84 uses the EGM96 (Earth Gravitational Model 1996) geoid, revised in 2004. This geoid defines the nominal sea level surface by means of a spherical harmonics series of degree 360 (which provides about 100 km horizontal resolution). The deviations of the EGM96 geoid from the WGS 84 reference ellipsoid range from about −105 m to about +85 m. EGM96 differs from the original WGS 84 geoid, referred to as EGM84.

- **Antenna Position**

Sensors which are used for position (like EPFS, Dual axis log and radar) are having common reference point, which is located on conning position.

- The values of Center and Conning positions are depending on size and geometry of the ship.
- Offsets from Antenna Position to Conning Position of Position Sensors depend on the location of Position Sensor antennas.
- Offsets from Antenna Position to Conning Position of Radars depend on the location of Radar antennas.
- Offset of transducer position to Conning Position of dual axis log depend on the location of dual axis log's transducer.

All the values are maintained in Installation parameters. During commissioning of system, engineer will set all the values for the system. End users have limited access to Installation parameters. This is controlled by a Authorizing key disc. The Authorizing key disc is a floppy which contains necessary key to allow access into editing of the installation parameters

- **Transducer Position**

A **transducer** is a device that converts a signal in one form of energy to another form of energy. Energy types include (but are not limited to) electrical, mechanical, electromagnetic (including light), chemical, acoustic or thermal energy. The term *transducer* commonly implies the use of a sensor/detector, any device which converts energy can be considered a transducer. Transducers are widely used in measuring instruments.

- The Doppler speed log measures ship's speed by using the Doppler Effect, which is observed as a frequency shift resulting from relative motion between a transmitter and receiver or reflector of acoustic or electromagnetic energy. A common example of the Doppler Effect is a train. When a train is approaching, the whistle has a higher pitch than normal. You can hear the change in pitch as the train passes.

  Doppler Log has a pair-beam, one directed in the fore direction and the other in the aft direction, which emits ultrasonic waves at an angle of θ to the waterline towards ship's fore and aft directions. The frequency of the received signal is then compared with that of the transmitted frequency to measure doppler shift to calculate ship's speed.

- **Echo sounding** is the technique of using sound pulses to find the depth of water. The interval from the emission of a pulse to reception of its echo is recorded, and the depth calculated from the known speed of propagation of sound through water. This information is then typically used for navigation purposes or in order to obtain depths for charting purposes.
  Echo sounder equipment makes use of sound (or sonic) waves, which differ from radio waves in several ways. Sound waves vibrate in the direction of travel of the wave front. Sound wave velocity is comparatively low (in comparison with radio waves). Sound waves can travel through a material medium such as a gas, a liquid or a solid, but not a vacuum.

  Short pulses of sound vibrations are transmitted from the bottom of the ship to the seabed. These sound waves are reflected back by the seabed and the time taken from transmission to reception of the reflected sound waves is measured. Since the speed of sound in water is 1500 m/sec, the depth of the sea bed is calculated which will be half the distance travelled by the sound waves.

  Satisfactory operation of an echo sounder depends on the transmission and reception of the largest possible signal for a given amount of power. The siting of the transducer is important in this respect to reduce attenuation on transmission and reception as far as possible. The ideal position is one in which there is "solid" water free from aeration beneath the transducer, and where the effects of surface, engine and propeller noise are at a minimum. There are few positions which are suitable in every respect and a position found to be satisfactory in one design of ship will not necessary give equally good results in another.

- **Clock or Time Source**

In some types of ECDIS, Time is being supplied by the GPS. Time from GPS, being more accurate, is considered to be the main one, and is used for system time synchronizing. Each time message (ZDA) is received from GPS (UTC sensor), check is made of the set 2 sec limit between the time from GPS and system time. If the difference exceeds this limit, time is equalized with GPS (UTC sensor).

CH. 14: CHART SELECTION

Once chart data is loaded into an ECDIS it can be easily viewed, in either of the two main modes of ECDIS, *route planning* and *route monitoring*. If the area covered by the ECDIS display includes waters for which no ENC at a scale suitable for navigation is available, there will be an indication on the display. In this instance paper charts must be used or an appropriate use of RCDS Mode.

It is an IMO requirement that by a *single operator action* it is possible to access immediately the route monitoring display covering own ship's current position. The action required will be detailed in the user manual. Own ship position will normally be displayed on the largest scale chart available in the center of the chart display. And assumption is made that the base chart data has been loaded that covers the actual position of own ship. In both route monitoring and route planning modes, it is also possible to enter the geographical coordinates of any position and display that position on demand. And the user manual will detail this operation.

14.1: Methods of Loading Chart Data

For a clear presentation of the sailing area and work with the chart information, it is necessary to correctly select the navigational charts and their scale. This kind of selection can be made automatically or manually.

Chart selection is understood as the display of an electronic chart being displayed the ECDIS task screen. Such loaded chart is referred to as the current chart.

For an easy search and loading of the required charts, the ECDIS task offers two procedures:

1) **Chart Autoloading**

   Chart autoloading is a special ECDIS task function, which allows the automatic display of the chart optimum in regard of its position and scale, and defines this chart as the current chart.

   The chart autoloading is performed in the following cases:
   • Under the ship position – when the ship sails beyond the current chart limits;

- Under the cursor – when the graphic cursor moves beyond the screen limits during the use of some functions (Review, ERBL, Zoom, WPT Editor, etc.).

Note:
Where it is necessary to use the chart which is not loaded automatically, a special function is provided which is activated by a special key in Chart toolbars. As this is done, the chart autoloading is disabled and required chart can be loaded manually. After the ship symbol has passed the boundaries of the fixed current chart, the autoloading mode will be turned on automatically.

2) Manual Chart Loading

The manual method of chart loading requires the operator to select the charts him/herself in the windows adapted for the search of charts. The selection can be made from the list of the entire ship folio which can be found on the CHART toolbar/Menu then and from the list of charts covering the ship position.

The required chart (or the one whose number is similar in the initial characters) is displayed and highlighted in the list. If the first character of the entered number matches no first characters in the numbers of charts in the provided folio, no chart is highlighted, whilst “No chart found” message will be displayed in the information bar.

Manual Loading or choosing a chart by its name on the display.
This can be done on ECDIS, please see maker’s manual.

14.2: Display of Updates

An ECDIS must be able to display a record of all ENC updates and at least include the following information:

- The identification number of the update as given by the relevant HO.
- The date and time of application or rejection of the update
- Any anomalies encountered during application
- Type of application (whether manual or automatic)

It is possible to display updates to review their contents and to ascertain that they have been included in the SENC. The record includes all the updates for each cell, until the cell is superseded by a new edition. It enables to easily assimilated view of the effects of applied updates in any particular area.

SENC delivery is an alternative method to the standard distribution and use of official ENC data. Developed by IHO’s Worldwide Electronic Navigational Chart Database (WEND) system, this method allows an authorized chart data distributor to perform the ENC-to-SENC conversion – that otherwise would have to happen inside the ECDIS – and deliver the resulting SENC to the end user.

It is possible for the ECDIS to determine if the SENC data being displayed is from either an ENC or a private source by use of the Agency Code (a two character combination which is unique for any data producer) embedded in the data. Using this code, the ECDIS is able to inform the mariners that they must navigate with an official up to date paper chart if SENC 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 »"**

14.3: Scrolling and Zooming ENCs

By zooming on a displayed ENC, the viewed scale is obviously being changed. To keep users aware of the scale of the actually displayed chart, a *scale bar* is always visible. This appears on the left-hand side of the chart as a vertical line, divided into equal length segments. If the compilation scale is 1:80,000 or larger the scale bar will be shown in terms of distance. If smaller than 1:80,000 it may be shown as latitude angle and then is correctly known as a *latitude bar*. In actuality, ENC cells have a *compilation scale* from which the user can zoom in or out from. The compilation scale can be taken in a practical sense to mean the scale that would be most normal to view the chart. However, there are many occasions when it is more appropriate to view it at different scales.

Depending on the ECDIS in use, different options may be available to set the desired scale. It may be possible to set any wanted scale by inputting the actual scale required. On some systems a menu of fixed-scale options may be given or, in effect, set with successive presses of the zoom controls. Alternatively, the user may be able to input the desired range of the chart display in nautical miles.

If an ENC is shown at a scale that has been over-reduced (under-scale), displayed features tend to clutter the display and so it can become a confusing picture. This becomes quickly self-evident, naturally stopping users selecting inappropriately small scales. Zooming into a scale that is larger than the compiling hydrographic office intended to be used (overscale) can be quite dangerous. This is because charts intended to be used at a large scale contain a lot of detail that is not included on smaller scale charts. Since it would not necessarily be evident to the user that data was being used overscale just by viewing an ECDIS display, a specific indication on the display that the information is overscale is given. When the display area covers more than one cell, it can be the case that only some of the ENC data shown is overscale. In this case the ECDIS will automatically display a distinctive pattern of vertical black lines in those areas. The pattern will generally only be displayed if it is shown more than twice the compilation scale and other parts of the display are not overscaled. Different interpretations of this are evident, dependent on equipment. If larger scale charts of the area that includes own ship's position are available, there will be an indication of this fact, generally indicated by a magenta frame around the area for which a larger scale is available.

It will always be the case that all information displayed will be at the same scale. However, some ECDIS units permit extra 'windows' to be opened that allow charts of different scale to be viewed simultaneously. The range scale and North marker should be visible in all windows and the delineation of separate windows should be clear.

An increasing number of ENCs are complied with *scale-related data*. This means that a certain data will only be displayed over a range of scales defined by the compiling hydrographic office by using the attributes SCAMIN and SCAMAX. This can greatly help in preventing screen clutter. For instance, certain buoys or soundings may not be shown below a certain scale. Unfortunately, it is very time-consuming for hydrographic offices to compile this data and so it is not yet universally applied, this is an instance of *Conditional Symbology*.

CH. 15: CHART INFORMATION

Chart information is stored in the form of a database containing all the geographic, hydrographic, administrative and geophysical information for the area that is traditionally provided by paper chart and over relevant publication such as sailing directions and list of lights. In addition, under operational conditions, all other information and events of navigational importance are stored and made available for display.
Data has to be specially prepared by the issuing body, such as the hydrographic office, to a closely defined format that is readable by the specific software within the electronic chart equipment. The preparation of *official data* is always performed by or on behalf of a national hydrographic office. The preparation has many inputs including, for instance:

- Raw depth and coastline, as collected nowadays by survey vessels, aircraft and satellites
- Seabed characteristics
- Defined position and attributes of aids to navigation, such as buoys and beacons, from data supplied by coastal authorities
- Defined positions and attributes of coastal authority defined areas, such as traffic separation zones, prohibited areas, port control boundaries and, where appropriate, national boundaries
- Positions of hazards and where care should be taken, such as underwater cables and pipes, wrecks, bridges and oil platforms.

15.1: Chart legend of S57 chart

The chart legend, which provides various data about the chart currently displayed, can be toggled on and off by placing the cursor in the sidebar, clicking the right mouse button, choosing Chart Legend from the menu and then pushing the scrollwheel.

This system is capable of showing more than one S57 chart at a time. This feature is called the multi-chart display. If one S57 chart does not cover the whole display, the system will open more S57 chart cells for display, if appropriate cells for the displayed area are available. The chart legend shows information about S57 charts displayed on the electronic chart display area. The information is displayed with reference to own ship position if automatic TM reset is active, or with reference to the current position of the cursor if automatic TM Reset is OFF.

S57 chart legend

Cell name	FI4EIIQR
Navigational purpose	Approach
Issue date	20010201
Edition number	1
Last displayed update	019
Update issue date	20010724
Last update appl. date	20010201
Projection	Mercator
Horizontal datum	WGS 84
Vertical datum	Approximate mean sea level
Sounding datum	Mean lower low water springs
Quality of data	Zone of confidence A1
Magnetic var.	
Depth	metres
Height	metres

Cell name: Name of chart.
Navigational purpose: An individual S57 chart has been compiled by a Hydrographic Office is indicated in this field. Alternatives are: Overview, General, Coastal, Approach, Harbour and Berthing.
Issue date: Issue date of the Base cell of the chart.
Edition number: Edition number of the chart.
Last displayed update: Number of last update, which is visible on the chart screen.
Update issue date: Issue date of last update, which is visible on the chart screen
Last update appl. date: Date to which the last update, which is visible on the chart screen, is effective.
Projection: Chart Projection. The projection is always Mercator.
Horizontal datum: Horizontal datum of the chart data as published by the chart producer. By definition this must be WGS 84.
Vertical datum: Vertical datum of the chart.
Sounding datum: Datum used for soundings.
Quality of data: Quantitative estimate of the accuracy of chart features, given by the chart producer.
Magnetic var.: Amount of magnetic variation. A positive value indicates a change in an easterly direction and a negative value indicates a change in a westerly direction.
Depth: Unit of measurement for depth.
Height: Unit of measurement for height above sea level (for example, clearance height).

15.2: Detailed Background Information (‘Info box’; ‘Pick Report’)

When using ENCs much of the available information concerning objects is not displayed because it would cause immense screen clutter. However, this information is easily accessed on an ECDIS, typically by placing the cursor over the object of interest and clicking the appropriate button or menu option to ‘pick’ the detailed information. The information available is often shown in a temporary box or window overlaying the chart or in a box outside the chart area; therefore it is also often called an *information box*, normally shortened to *info box* (others called it as ‘*Pick Report*’). An example of the information given when placing the cursor over a particular buoy is shown in Fig. 15.1.

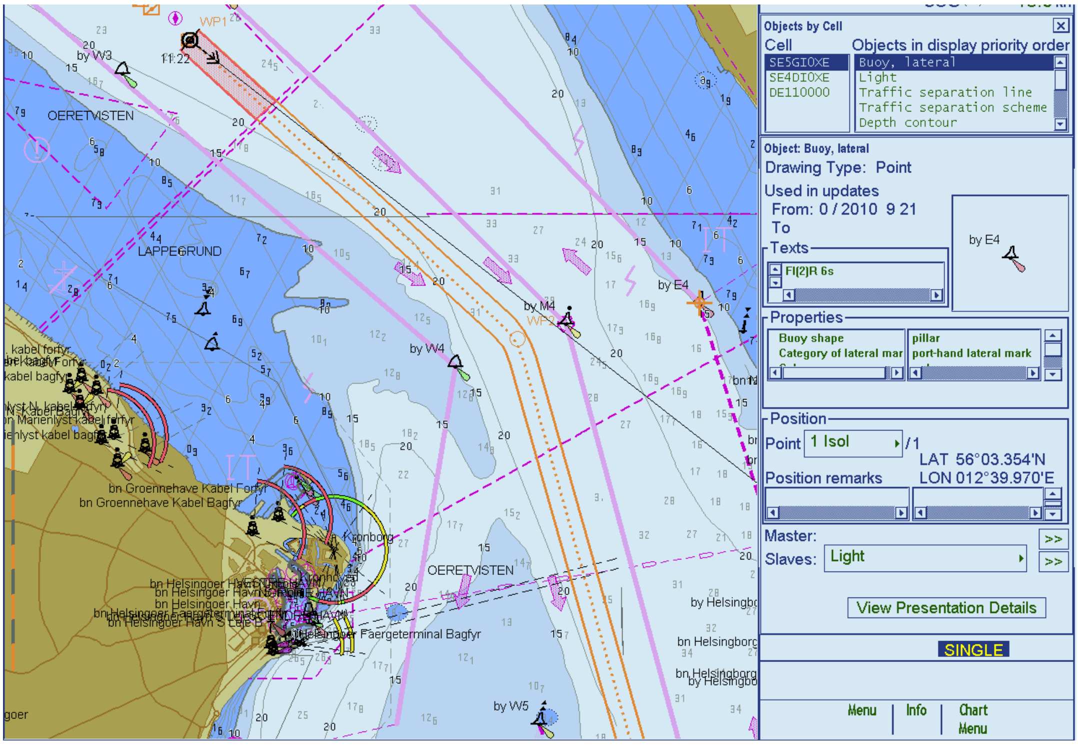


Fig. 15.1: Information obtained on a selected buoy

The information covers more than just the buoy. This is because al geographical positions on an ENC coincide with one or more area-defined objects, such as the limits of a port, the area between two depth contours, the nature of the seabed, etc. most ECDIS just display the pick report in a consistent order of items. The list can be long and may need to be scrolled in order to view the items required.

Besides object-related information, a ‘Pick Report’ may also provide information about operational matters, e.g.:

- The info box for a radio call-in point gives detailed information on the call-in duties (type and size of ships which have to report, VHF channels, etc.);
- The info box for a pilot boarding place provides information about position, way of boarding and communication channels.

This enables the Watch Officer to find out the duties of his ship (depending on type and size of the ship). In principle, the ‘Pick Report’ takes over the role of other special nautical publications such as of the list of lights, the sailing directions and the VTS guide. The ‘Pick Report’ window is normally placed in an area on the screen where it does not obscure the selected feature.

It is not possible to access data this way on an RNC. However, specific data areas on the chart, such as ‘Notes’ can be quickly brought into view from the menu structure as part of the IMO requirements for the use of RNCs.

CH. 16: CHANGING THE SETTINGS

(See Model Course as this topic shall be included as an activity)

16.1: Manually Testing the Major Functions of Hardware

- **Self Test (RCU-018)**

- **Color Calibration (RCU-018):**

  Color Test for ARCS Charts
  In the ARCS Colors window, you can see if individual colors can be distinguished when viewing. This lets you see how light levels may affect the visibility of the chart.

  Color Differentiation Test for S57 Charts
  This tool is the color differentiation test diagram.

  Gray scale test
  Set brilliance and contrast to calibrated positions. Use to test and visually inspect neutral shades of grey.

CH. 17: CHART SCALING

ENCs are produced at a compilation scale, which is decided by the hydrographic office developing the particular ENC. It is simply based on what is sensible when taking into account the scale of the survey information within the ENC. The IHO recommends that the compilation scales are based on the radar-like ranges defined in Table 17.1

Table 17.1 Recommended Compilation Scales

Selectable Range (NM)	Standard Scale (rounded)
200	1:3,000,000
96	1:1,500,000
48	1:700,000
24	1:350,000
12	1:180,000
6	1:90,000
3	1:45,000
1.5	1:22,000
0.75	1:12,000

0.5	1:8,000
0.25	1:4,000

The compilation scale is now generally understood to mean *scaled to optimize the viewing capabilities in a digital environment, usually a 21 inch monitor.* A user does not have to display the chart at its compilation scale but it is worth remembering that the data will normally have maximum clarity in normal circumstances when so viewed.

ENCs are typically assigned to one of six navigational purpose categories, with associated scale ranges, as shown in Table 17.2.

Table 17.2. Assignment of Navigational Purposes to Scale Ranges

Navigational Purpose Band	Name	Scale Range
1	Overview	<1:1 499 999
2	General	1:350 000 – 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	>4 000

17.1: Choice of Sea Area

♦ The Chart Around Own-Ship

The immediate sea area around own-ship's current position is normally displayed during route monitoring. When the vessel is moving in an ENC-based electronic chart, the chart area being displayed is adjusted automatically, using a certain internal 'Frame', to show the next neighboring area. When using RNC data, individual charts must be called up. For convenience, several charts can be loaded in advance.

♦ Selecting Charts of any Other Sea Areas

In order to manually call up and display any sea area which does not contain own ship's position, e.g. for route planning purposes, the manufacturers use various procedures:

- A world chart or globe which the user may zoom-in and 'center' for the desired sea area;
- A list of names (places, ports) from which the user may select the desired sea area;
- A geographical position using as numerical input.

For raster charts, normally a list (with titles or area names) of available charts is presented to the user, and he may select the chart from the list.

17.2: Scale, Range and Usage of a Chart

Overview – 'Range' instead 'Scale'
The scale of an electronic chart being displayed (both the compilation scale of the chart and current screen-related scale) is up to the user to decide. It could be from a general track overview chart (small scale) to a highly detailed harbor plan (large scale). In general, there are three different ways by which the chart scale can be described:

- Natural scale (e.g. 1:5,000 or 1:75,000);
- Display range (e.g. 3, 6, 12 or 24 nm);
- Chart usage (e.g. 'Harbour', 'Approach' or 'Coastal').

On paper charts, the scale is given as a ration, termed the natural scale (e.g. 1:100,000). A distance on a chart must be measured on the chart's edge with a pair of compass dividers. When using an electronic chart display, it may be desirable to express the scale – like in radar – through the display 'Range' in nautical miles (nm). The set 'Range' (e.g. 6nm) corresponds with the distance from the center of the chart to the top and bottom edge. Because own ship's symbol is usually not far from the center of the chart, display range is, in many voyage monitoring situations, similar to the 'visual' range. A change of 'Range' from e.g. 6 to 3 nm takes only a few seconds. This method is intuitive, and also accommodates the overlaying of the radar image. Similar to what is done with radar, most systems allow the display 'Range' to be changed in reasonable steps.

Vector Charts – 'Range' Decide Whether a Buoy is Displayed
When using vector chart data, the display is most easily adapted to the users' needs. The amount of displayed information (objects, symbols, names) depends on the set display 'Range' (or scale):

- By decreasing the 'Range' (i.e. increasing the scale), more detailed navigational information will be displayed automatically;
- Conversely, when displayed at a larger 'Range' (i.e. smaller scale), the image becomes more generalized. At larger 'Range', information will be cut out in order to avoid chart clutter.

The selected "range' decides, for instance, whether a certain buoy is displayed or not. The buoy may not be shown on an overview chart. However, it will appear when a certain purpose of a chart is defined, or a certain 'Range' (or chart scale) is attained. The Watch Officer only has to change the 'Range' to get more or less details displayed. Internally, this automatic and range-related display of details is managed by two procedures:

1. **Chart content according to chart 'Usage'**
   The ENC data used in ECDIS is assigned a certain 'Usage' or 'navigational purpose'. ENC data are classified by the IHO, in practice, according to their use in six various types of usage with typical cell sizes:
   - Overview (1000 – 200 nm);

- General (100 – 60 nm);
- Coastal (48 – 24 nm);
- Approach (18 – 8 nm);
- Harbour (6 -2 nm);
- Berthing (1.5 – 0.1 nm).

The display of details (i.e. object classes) in every chart display depends primarily on its usage. Consequently, a certain navigational object is shown on the 'berthing usage' chart display because it is needed for coming alongside, but it does not appear on an 'approach usage' chart display. For example, when approaching a harbor, the main chart display of 'approach usage' type contains two other usages in the relevant areas of the chart: a 'harbour usage' (where the chart quality is higher) and 'coastal usage' (where the chart quality is lower). When for a given chart area, charts of different usages are available within the system, the chart of 'better usage' is automatically displayed when a certain 'Range' (scale) is reached. The (often visible) effect of neighboring area cells of different usage is called '***source break***'.

2. Chart content according to 'SCAMIN'

An important feature that could lead to human/operator error where the users need to be very careful is known as Scamin (Scale Minimum). Scamin is an optional attribute by the chart producer (defined by IHO S57) that can be used to label ENC chart features to be suppressed above a certain display scale. The main function of Scamin is to de-clutter the chart display, enabling the user to focus on the most useful navigational information for the display scale in use. Scamin may affect the display as it removes certain information from the display.

Within a certain usage, the attributes 'SCAMIN' (scale minimum) and 'SCAMAX' (scale maximum) of any object are also used to define in which scales the object is displayed or not. For example, a buoy will be displayed only in those chart ranges in which, in the given usage, a certain scale (like 1:25,000 to 1:5,000 is applied.

Figure below illustrates the effect of the attribute 'SCAMIN'. The sailing area (Elbe approach; German Bight) is displayed in both 10 and 3 nm ranges. Both chart displays are based on the same ENC (compilation scale 1:25,000). Whereas detailed information such as spot soundings, additional buoys, wrecks, radar lines, special areas, descriptions, etc. do not show up in the 10 nm range chart. This is because, in the 10 nm range chart, the scale in use is smaller than the SCAMIN value of the objects involved, whereas in the 3 nm range chart the scale in use is larger than SCAMIN. As discussed, the wealth of detail varies not only between different usages of the chart, but also within a given usage by different scales.

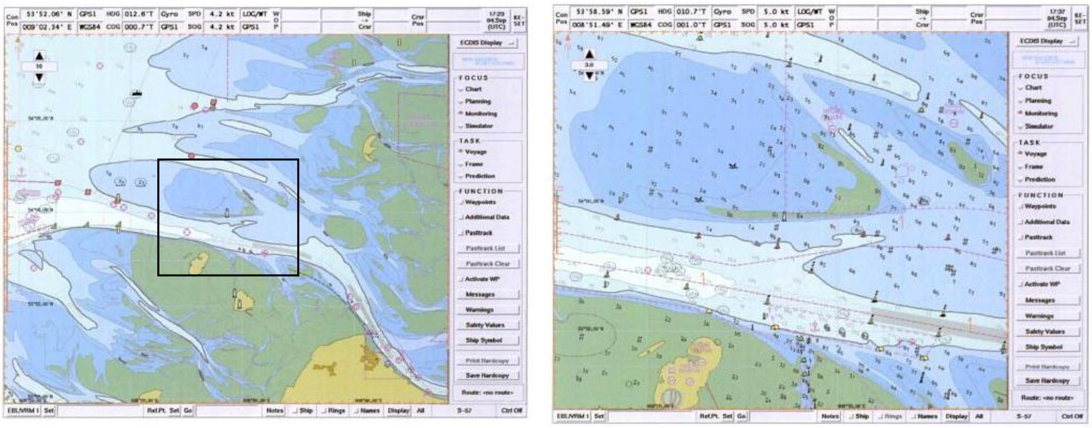


Fig. 17.3: Details of chart display according to 'SCAMIN' (range)
a) Range 10nm: little detailed chart content (left side)
b) Range 3nm: detailed chart contents (right side)
Compilation scale of both charts 1:25,000. Sea area: Elbe estuary.
Source: HDW-Hagenuk. Data: BSH.

Navigators must exercise extreme caution when using the scale or zoom facility of the electronic charts. It is possible to zoom-in to a scale larger than that used in the compilation of the data which could create a false impression about the reliability of the charted information. Consequently, it could give a false impression of safe water around the vessel where some hazards to navigation may not be shown due to the limitations imposed by original chart scale. It could also give the impression that the position of charted features is known to a greater degree of accuracy than is in fact the case. In the event that the chart is not displayed at the compilation scale (In ECDIS the Scale at which the Chart data was compiled) and is therefore not compatible with the selected usage (e.g. coastal or approach), then an over-scale or under-scale warning is displayed.

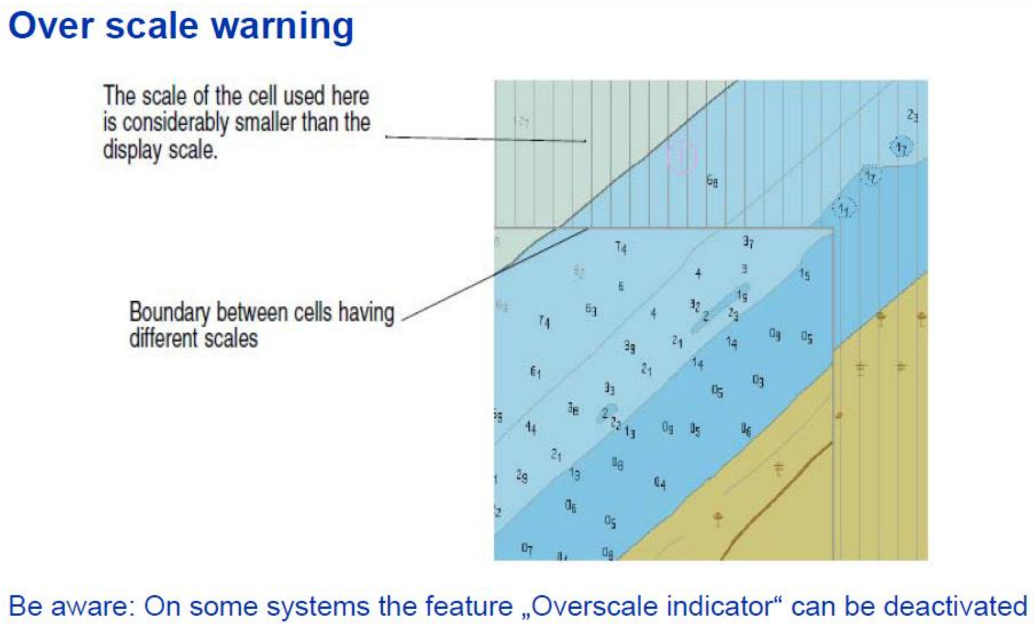
3. Practical use: Range-related indications to the Mariner

In general, a change of scale of the SENC should be made only in justifiable limits which are based on the purpose and the original compilation scale of the basic chart (ENC). ECDIS provides indications to prevent false interpretation of information in the case of 'false-zooming':

- **'Over-scale' indication**

  If the chart information is displayed in a scale large than that in which the underlaying ENC data have been complied,
  - The quality and accuracy of the chart can no longer be trusted and;
  - The display of detailed information on the chart is exhausted.

  The 'Overscale' status is generally indicated by a thin black vertical line pattern all over the relevant chart areas.



- **‘Under-scale’ indication**
  If for a given sea area another chart in a compilation scale larger than that offered by the display is available and should be used, this is indicated to the Watch Officer. To make proper use of this chart, i.e. to get the better ‘Usage’ and to display more detail information, he has to decrease ‘Range’. The ‘Under-scale’ status is generally indicated by a coloured frame around the area of this chart – as in the case of ‘harbour usage’ available. Nevertheless, under-scale presentation may be accepted during route planning to display a larger sea area.

Raster Charts
In raster charts, the individual objects cannot be identified like in ENCs. Therefore, the benefit of changing range (or scale) is limited. A change can be accomplished in two ways:

- Within certain limits, a scale change can be carried out without switching to another chart. In this case, all items of the display (symbols, lines, areas, numbers, names) can be optically enlarged (zooming-in) or reduced (zooming-out). However, no additional details of navigational information are provided;
- A completely new chart for the area in a different scale is loaded. Similar to shifting to a paper chart of a larger scale, more detailed information is presented.

CH. 18: INFORMATION LAYERS

18.1: Additional Layers
The provision of supplemental information that is in addition to that which is shown on a paper nautical chart is specifically mentioned in the IMO Performance Standards for ECDIS. In particular, the definition of an ENC states that it should contain *‘all the chart information necessary for safe navigation and may contain supplementary*

information in addition to that contained in the paper chart which may be considered necessary for safe navigation'.

There are two main types of supplemental information that have been developed and are being implemented: Marine Information Objects (MIOs) and Additional Military Layers (AMLs).

- **Marine Information Objects (MIOs)**
  Marine Information Objects (MIOs) is a generic term used to describe chart and navigation-related information that supplement the minimum information required by ECDIS to ensure safety-of-navigation at sea. As it relates to the use of Electronic Navigational Chart (ENC) data, MIOs are additional, non-mandatory information not already covered by existing IMO, IHO, or IEC standards. Currently, this includes ice coverage, tide/water level, current flow, meteorological, oceanographic, and marine habitats. The supplemental information can be provided as proprietary or IHO S-57 data format (e.g., objects/attributes). However, MIOs can also be in the form of imagery, graphics, or gridded data.

  The basic concept of MIOs is to provide a supplemental layer of information (e.g., points, lines or areas) that can be displayed in conjunction with existing electronic chart information. While often highly useful, MIOs are primarily intended for 'informational purposes'. However, several types of electronic navigation equipment (including GPS chart plotters, ECS or ECDIS) can be programmed to provide an indication or alarm that there is something in the MIO that the Mariner needs to be particularly aware of or concerned about.

  In the most basic sense, there are two categories of MIOs: static and dynamic. A static MIO is relatively fixed or constant information that is not subject to continual change. This includes previously compiled, predicted and forecast information such as marine habitats, seafloor geology, regulated areas, and long-range weather forecasts. Dynamic MIOs are more temporal and deal with real-time. Examples of dynamic MIOs include real-time transmission of water levels or currents that are continually being updated. However, these two categories are not mutually exclusive and there can be a combination of predicted, forecast, and so-called 'now-cast' (i.e., a forecast that is continually being updated) information. It should also be pointed out that the use of MIOs in electronic charting systems is similar in both concepts and practice to using a variety of geo-spatial data in Geographic Information Systems (GIS).

  In 2001, a Harmonization Group on MIOs (HGMIO) was established between IHO and IEC to recommend additional data and display specifications that may be incorporated into future editions of IHO and IEC standards. This involves a wide range of supplemental information including:

- Bathymetric (particularly gridded data);
- Ice coverage;
- Tides (real-time, predicted, and forecast);
- Geophysical data (seismic, gravity, magnetic);
- Seafloor bottom structure/physiography;
- Sonar imagery (sidescan, multibeam, LIDAR);
- Horizontal datum parameters;
- Salinity and temperature profiles;
- Sediment type/classification;
- Current flow (velocity, direction, time of occurrence);
- Satellite imagery;
- Aerial photography (orthogonal and oblique);
- Remote Operated Vehicle (ROV)/Autonomous Underwater Vehicle (AUV) video imagery;
- Archeological (wrecks, cultural heritage sites);
- Marine environmental protection (particularly sensitive sea areas).

As of mid-2005, MIOs have been developed for ice coverage, tide/water level, current flow, meteorological, and marine habitats.

Additional Military Layers (AMLs)

NATO Performance Standards for 'Warship' ECDIS (WECDIS) were developed by NATO to supplement those required by IMO for ECDIS. While the basic navigational functionality for WECDIS is the IMO Performance Standards for ECDIS, the NATO WECDIS Standardization Agreement (STANAG 4564) specifies additional functionality to enhance the navigational and military warfare capability. Two key aspects of WECDIS are the ability to use a variety of electronic chart data (e.g., IHO S-57 ENCs, NATO DIGEST VPF/DNC, UK ARCS®, NOAA/Maptech RNCs etc.), and the capability to display additional military layers (AMLs) of information for various warfighting missions (e.g. mine warfare, anti-submarine warfare, and littoral warfare). In particular, AMLs contain specific warfare-related information (e.g., mine-like contacts, submarine transit lanes, Q-routes, etc.) in addition to the core or auxiliary navigation information required for safe navigation.

As defined in the NATO Standardization Agreement for Additional Military Layer (AML) (STANAG 7170), an AML is defined as, 'a unified range of digital geospatial data products designed to satisfy the totality of NATO non-navigational maritime defence requirements'. AML Product Specifications have been developed for a variety of military missions/applications such as command and control, route areas and limits, bathymetric contour, mine counter-measures, wrecks and major bottom objects, seabed environment, anti-submarine warfare, and oceanography. Table 18.1 provides a listing of the nine (9) product specifications that have been developed or are planned.

Product Specification	**Acronym**	**Component**
Maritime Foundation and Facilities	**MFF**	Framework Port Facilities Miscellaneous Military Information

Routes, Areas and Limits	**RAL**	Routes, Areas and Limits (including aeronautical information)
Large Bottom Objects	**LBO**	Large Bottom Objects/Wrecks
Contour Line Bathymetry	**CLB**	Low resolution bathymetry contours for planning etc. Bathymetric Contours – Tactical Bathymetric Contours – Submarine Navigation Bathymetric Contours – MCM/Amphibious
Environment Seabed and Beach	**ESB**	Mine-Hunting Environment Beach – ‘patch’ Beach Overlay Low Resolution Seabed Information
Small Bottom Objects	**SBO**	Small Bottom Objects/MCM Contacts
Network Model Bathymetry	**NMB**	Low Resolution Bathymetry for Oceanographic modeling etc. Bathymetric Model – Tactical Bathymetric Model – Submarine Navigation Bathymetric Model – MCM/Amphibious
Integrated Water Column	**IWC**	True Water Column Components
Atmospheric & Meteo-rological Climatology	**AMC**	Meteorological Climatological Information
Digital Catalogue	**DCA**	[Note: to be developed in conjunction with other groups to produce a common catalogue product]

Table 18.1: AML Product Specifications and Associated Components. [Source: NATO STANAG 7170]

Some Limitations on the Use of MIOs and AMLs

There are at least three challenges regarding the provision and use of MIOs and AMLs:

1) Agreeing on what constitutes appropriate data contents and suitable formats;
2) The means/process required to provide this information in a timely fashion;
3) How the information should be displayed and used.

While it may not be feasible (or desirable) to try ‘standardize’ all types of MIO data/information, there is a need to consider each in the context of existing or planned standards (e.g., IHO S-57/S-52, IEC 61174 and 62288, or ISO TC211). Also, while there are benefits for the next edition of IHO S-57 (Edition 4) being able to make provision for MIO-related information that includes temporal, raster, and matrix data, there is a less compelling need to specify specific colours or symbols that must to be used.

For merchant vessels that normally transit well-established routes, the rapid dissemination of MIOs is not usually critical for safe passage. However, this is not always the case for military vessels that operate in unfamiliar waters. AMLs provide the means to exchange critical military specific navigation or warfare-related information that are essential to the planning and execution of an operation. Often, this information is classified and highly time-sensitive. A long delay in chart-related AML information could result in an unacceptable risk.

One way to view these challenges is in the context of a 'Want-Get-Use' Dilemma (also known as the 'Three Rules of Military Intelligence'):

Rule 1 What you want you cannot get (even if you know it exists);

Rule 2 If you get it, you cannot use it (e.g. unrecognized data format, wrong type of equipment, out-of-date software, unintelligible display, lack of geo-reference, etc.);

Rule 3 When you can finally use it, the information is now of date (back to Rule1).

18.2: Day and Night Display (Colour Modes)

The indications on electronic charts must be recognized and distinguished quickly and safely under all lighting conditions – from very bright daylight to darkest of nights. In addition, working on the electronic chart in darkness must not impair the night vision of the Watch Officer since the adaptation to darkness can take as long as 30 minutes. Paper charts depend on exterior light. For this reason, they are usually kept in the rear section of the bridge and they must be curtained off during the darkness. Electronic charts offer much better possibilities.

However, due to technical considerations (different colours are affected by their individual 'temperature'), it is difficult to change the variety of colours of the chart display satisfactorily by simply adjusting a single 'brightness' control. Therefore, ECDIS uses three different 'colour modes', specified by IHO [IHO S-52 – App 2, 1996]. These colour modes represent colour palettes. They can be selected depending on the prevailing light conditions for

- 'DAY'
- 'DUSK'
- 'NIGHT'

use by the 'brightness menu'. Whereas the 'DAY' colour mode uses a white background to achieve the best contrast under near-washout conditions, in the 'NIGHT' mode the light emitted is strictly limited. In the dark display, the colours are partly preserved (green, red and yellow colour of buoys); partly darkened (land areas) and partly inverted (depth contours, depth areas), i.e. what is shown light in the day display will be shown dark in the night display, and vice versa.

Some systems offer in addition to color displays, a grey-mode option where only the important navigational objects (e.g. buoys) are shown in colour (red, green, yellow).

The change from day to night presentation can also be provided for raster charts. In this case, it is the colour of the pixels that is converted, independent of the symbol (object) to which the pixels belong to.

18.3: Color Palettes for the User Interface

There are several color palettes available for choosing colors for the chart background and information areas.

Setting	Background Color of Chart	Background Color of Information Area
Day Bright	Light-Blue	White
Day Blue	Light-Blue	Dark-Blue
Dusk	Blue	Black
Dusk Blue	Blue	Dark-Blue
Night	Black	Black

With any palette selection except Day Bright, text is shown in different colors to help you distinguish between them. For example, dynamic data like your ship's position, time or direct control of parameters (scale, predictor time, etc.) is shown in yellow color.

Note: The display colors may change to the Windows standard color palette whenever a USB memory device is inserted or removed. (When Windows initiates USB recognition procedures, the Windows standard color palette is restored.) To restore the ECDIS color palette, open the Chart Display menu and follow the procedure on this page.

18.4: Mariner's Note and Danger Highlights

The 'Mariner's Notes' function can be used to enter text, symbols and simple graphics manually onto the electronic chart display in order to record events or to make notes requiring attention. The following options are available:

- **Text**
  Typical examples include: 'Wheel over'; 'Time to turn', 'Call Pilot 16:00', or the famous 'Wake up the captain'.
- **Symbols**
  Pre-defined symbols are provided to make various notes, e.g. 'Event', 'Remark', 'Caution'
- **Graphics**
  Simple graphics like lines and areas (as polygon sequences) can be drawn with the help of a track-ball.
- **Highlight Danger**
  Dangerous objects can be drawn, e.g. by polygons, and marked in red color suing the 'Highlight Danger' function.

Different electronic chart system manufacturers may provide additional symbols or graphics.

Ch. 19: SYSTEM AND POSITION ALARMS

19.1: Indicators, Alarms and Warnings

Since the ECDIS is a "smart" system which combines several different functions into one computerized system, it is possible to program it to sound alarms or display warnings when certain parameters are met or exceeded. This helps the navigator to monitor close navigation hazards. For the purpose of clarification an ALARM or alarm system is one which announces by audible means, or audible and visual means, a condition requiring attention while an INDICATOR is a visual indication giving information about the condition of a system and/or equipment.

Alarms consist of ***audible*** and ***visual*** warning. The navigator may determine some set points; he may designate a safety depth contour or sea a maximum allowed cross-track error. Operational details vary from one system to another, but all ECDIS have the basic alarm capabilities noted. The navigator is responsible for becoming familiar with the system aboard his own ship and using it effectively.

IMO standards require that certain alarms be available on the ECDIS.

- Deviating from a planned route;
- When the specified limit for deviation from the planned route is exceeded (including when in RCDS mode);
- When the input from the position fixing system is lost;
- Chart on a different geodetic datum from the positioning system;
- Approach to waypoints and other critical points;
- Manually entered points, critical points, lines, and areas (including when on RCDS mode) for which alarm may be required;
- When the ship crosses a point, line or is within the boundary of a mariner-entered feature within a specified time or distance;
- Exceeding cross-track limits;
- Chart data displayed over scale (larger scale than originally digitized)
- Larger scale chart available;
- Failure of the positioning system;
- Anchor watch during anchorage;
- Vessel crossing safety contour;
- System malfunction or failure;
- Own ship crosses the Wheel Over Position;
- CPA/TCPA alarm etc.

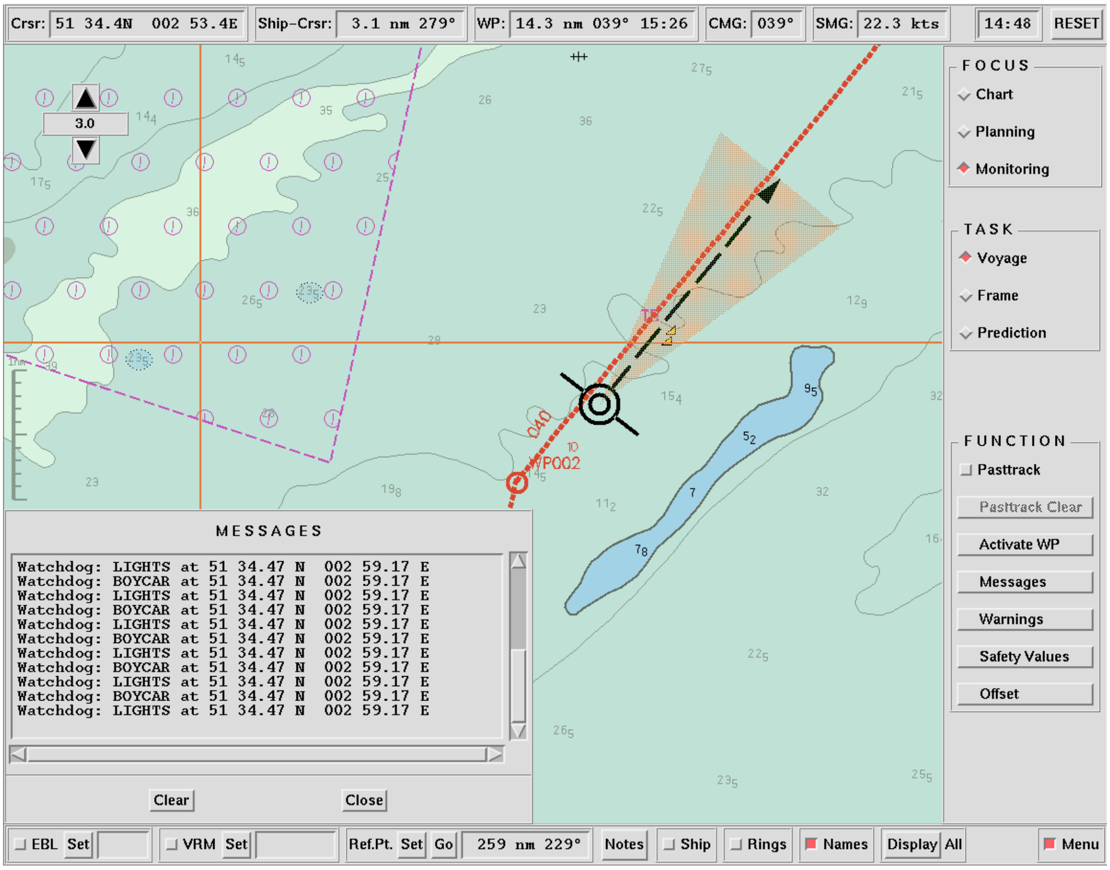


Fig. 19.1: Warning of anti-grounding system

INDICATORS

Setting shall be such that an indicator shall be activated at following occasions, but not limited to:

1. Crossing safety contour (grounding)
2. Approaching area with special conditions
3. Cross track error
4. Approaching critical point
5. Geodetic datum mismatch
6. Malfunction of ECDIS
7. Information over-scale
8. Larger scale ENC available
9. Route planning across safety contour
10. Route planning across special area
11. Positioning system failure
12. System test failure

Alarm text : The last unacknowledged alarm is displayed here on a red background. When there are no unacknowledged alarms the area is grey.

Alarm categories **:** Unacknowledged alarms are displayed on a flashing red background. Acknowledged alarms where the alarm situation still exists are displayed on a steady red background.

- Steady red background: Push **WARN** or **FAIL** to display a list of acknowledged alarms.
- Flashing red background: Push **WARN** or **FAIL** to display a list of unacknowledged alarms.

The following alarms message types are used:

Critp **:** Alarm for critical points, defined by the operator during route editing.
Area **:** These are part of the chart, such as for restricted areas.
XTE **:** When the cross track error is larger than the set limit.
GND **:** Grounding alarm based on chart information (not echo sounder). Requires that the vector charts are being used. The alarm will be given when an obstacle is closer than the set limit.
Warn **:** System warnings. Push the **WARN** button to display a list of warning messages, if any.
Alarm **:** System alarms are reported when an equipment malfunction is detected. Push the **Alarm** button to display a list of alarm messages, if any.
Help text **:** Below the alarm buttons there is a help text area. There are three types of help texts:
Information **:** Black text on grey background.
Advice **:** Black text on yellow background.
Correction **:** Flashing black text on yellow background.

Warnings given on Track Keeping

The following warnings related to the automatic track keeping are given:

- XTE-limit is exceeded.
- Time to Wheel Over Position (WOP) = 3min
- Time to Wheel Over Position (WOP) = 30 sec
- Control of steering is taken at the Track Pilot or by manual override.
- Communication failure between the Track Pilot and ECDIS
- The last waypoint in route is reached.
- Loss of position data from Navigation Receiver.
- Loss of Gyro input.
- Loss of Speed Log input.

Alarm Summary
Summary of alarms and indications required in ECDIS as per Performance Standard IMO 817 (19)

(i) **Alarm:** An alarm or alarm system which announces by audible means, or audible and visual means, a condition requiring attention.

(ii) **Indicator:** Visual indication giving information about the condition of a system or equipment.

REQUIREMENT	BRIEF INFORMATION
Alarm or Indication	Largest Scale for Alarm
Alarm	Exceeding off-track limits
Alarm	Crossing Safety Contour
Alarm or Indication	Area with special Conditions
Alarm	Deviation from route
Alarm	Approach to Critical Point
Alarm	Different Geodetic Datum
Alarm or Indication	Malfunction of ECDIS
Alarm	Position System Failure
Indication	Information Over-Scale
Indication	Larger Scale ENC available
Indication	Different reference system
Indication	Route Planning across safety contour
Indication	Route planning across specified area
Indication	System test failure

19.2: Automatic Route Steering Alarms

There are two types of alarms relevant to route steering, permanent and intermittent.

Permanent Alarms are available regardless of the steering mode used:
• Outside channel is indicated by displaying the text **"Outside Channel"** in orange and its value in red.
• The text "Out of Gate" is orange. Out of gate indicates that, if the ship continues using the current course, then the vessel will be outside of the channel at the wheel over point.

Permanent Alarm below is available only during route steering mode:
Rate of Turn Limit is indicated by orange text.

Intermittent audio/visual alarms appear as follows:
- Visual alarm and buzzer is located in ECDIS control unit.
- Alert number and text are visible at lower right corner of the ECDIS

19.3: Typical Intermittent Alarms: (Example only)

Alarm "**2457 Route: Outside chl limits**"
Alarm "**2455 Route: off course**",.
Alarm "**2456 Route: WPT approach error**"
Alarm "**2460 Pilot: ROT will be exceed**"
Alarm "**2461 Route: ROT will be exceed**"
Alarm "**2469 Autopilot: off course**"
Alarm **"2471 AP mode Conflict – use AUTO"**,
Alarm **"2475 Route: Needs filter on"**,
Alarm **"2476 Route: Needs log sensor"**,
Alarm **"2488 Integrated Steering Lost"**,
Alert "**2497 Route: Stop - Sensor Fail**"
Alarm **"2506 Route: Use AUTO Control"**
Alarm **"2511 Route: Auto Resume Disable"**,
Alarm **"2512 Use NFU Rudder Control"**,
Alarm **"2514 Route: Complete Turn**
Alarm **"2515 Conflict – NAVI Compl. Turn"**
Alarm **"2516 Autopilot: Drift Limit**

CH. 20: DEPTH AND CONTOUR ALARMS

20.1: Route Monitoring Alarms

As specified in Appendix 5 of the IMO Performance Standard, ECDIS must provide an indication of the condition of the system and its components. An alarm must be provided if there is a condition that requires immediate attention. An indication can be visual, while an alarm must be either be audible, or both audible and visual.

- Crossing a Safety Contour

The ECDIS can detect areas where the depth is less than the safety contour or detect an area where a specified condition exists. If you plan a route or if prediction of your ship movement goes across a safety contour or an area where a specified condition exists, the system will display a visual alert or sound an audio alarm to alert you to impending danger. For this function, the ECDIS utilizes the chart database (S57 charts) stored on the hard disk in SENC format. ***Note that the ECDIS calculates dangerous areas using the largest scale chart available, which may not be the visualized chart.***

You can select objects that are included for calculation of danger area (for example, restricted areas). A window lists the various areas that activate danger warnings.
You can also define your own safe area by creating a user chart area. The system can utilize these areas when calculating chart alerts. This is very useful with raster chart material such as ARCS.

The ECDIS can check the following for you:
• Predicted movement area of your ship
• Planned route with an easy to use locator function to find dangerous areas

The ECDIS will highlight the following for you:
• Dangerous areas inside predicted movement area of your ship
• Dangerous areas inside your monitored route
• Dangerous areas inside your planned route

- Prohibited Area

There are the areas that the ECDIS detects and provides the audio alarm or visual indication if estimated your ship's position or planned or monitored route cross the area defined on the Chart Alerts page. You can select from the following areas:

Fairway	Cargo Transhipment Area
Restricted Area	User Chart Danger
Caution Area	Traffic Separation Zone
Offshore Production Area	TRS Crossing/Roundabout
Military Practice Area	TRS Precautionary Area
Seaplane Landing Area	Two Way Traffic Route
Submarine Transit Lane	Deep Water Route
Fishing Ground	Recommended Traffic Line
Pipeline Area	Inshore Traffic Zone
Cable Area	Ice Area
Anchorage Area	Channel
Anchorage Prohibited	Fishing Prohibited
Dumping Ground	Spoil Ground
Incineration Area	Dredged Area

Note: Areas To Be Avoided and Specially Protected Areas are collections of certain types of areas. If you choose either of them, a group of areas will trigger an indication or audible alarm. The table below shows which areas are chosen if Areas To Be Avoided or Special Protected Areas is chosen.

Areas To Be Avoided	**Specially Protected Areas**
Fairway	Fishing Ground
Restricted Area	Pipeline Area
Caution Area	Cable Area
Offshore Production Area	Anchorage Area
Military Practice Area	Anchorage Prohibited
Seaplane Landing Area	Dumping Ground
Submarine Transit Lane	Incineration Area
	Cargo Transhipment Area

- Track Error Allowance

Cross track error is the distance the vessel is to one side of the straight line between two waypoints or from a planned track. An XTE can be generated if:

- You enter Track mode when positioned some distance from the planned route.
- You make a manual course change to avoid an object.
- You arrive at a waypoint

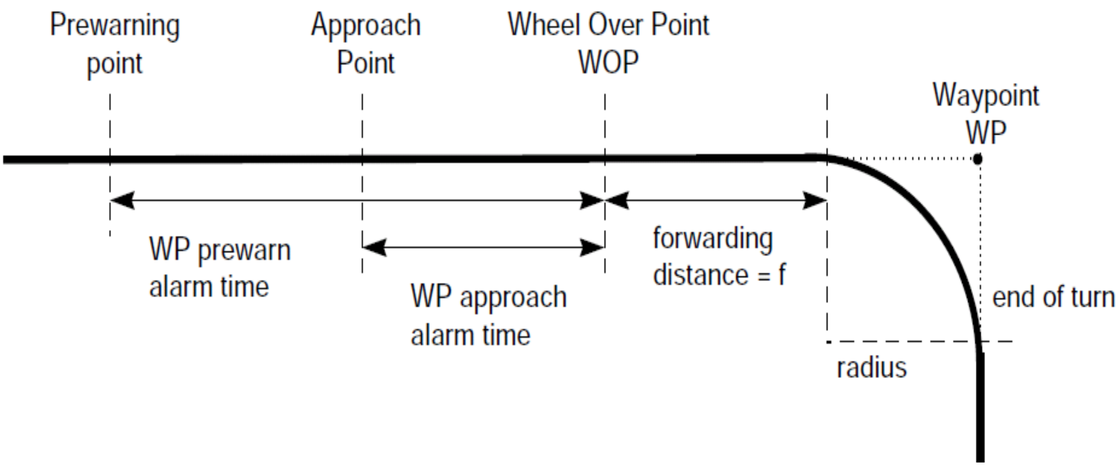
- Waypoint Arrival Circle

Automatic route steering navigation tries to keep the ship always inside the channel limits and going to next waypoint. Well before the next waypoint, there will be an alert **ROUTE WPT PREWARNING**. As soon as the alert appears verify that the maneuver is safe and there are no dangerous targets. If the maneuver can be performed press the **ALERT ACK** pushbutton on the ECDIS control unit. If the maneuver is impossible you can leave the automatic route steering changing "NAVI" to "AUTO" or to "HAND" mode in YOKOGAWA autopilot control unit.

Turn is always enabled. The only way to disable the automatic turn is to select another steering mode except "NAVI" from Yokogawa Autopilot.

Note that the alert is programmable (the time before turn) and it is relative to the starting point of the maneuver.
At the moment the next waypoint is about to be reached, there will be a second alert "**Route: WPT approach alert".**

Note that the above alert is programmable (the time before turn) and it is relative to the starting point of the maneuver.



As soon as the ship arrives to the wheel over point the ECDIS sends a new course command to the autopilot and the manoeuvre is started. During a manoeuvre the radar display and ECDIS display shows the CURVED EBL indicating the planned radius for manoeuvre.

After acknowledge of **alert ROUTE: WPT prewarning"** the text "**Ass. Appr. enabled**" appears in Route Monitor window of ECDIS display.

After acknowledge of the waypoint approach **alert** the text "**Ass. Turn enabled**" appears in Route Monitor window of ECDIS display.

During the turn the text "**Assisted Turn**" appears in Route Monitor window of ECDIS display.

Note: Approaching the last waypoint will give an alert "**Route: Last WPT approach".** With YOKOGAWA autopilot one should leave "NAVI" mode of the YOKOGAWA autopilot before performing acknowledge of the alert. This will terminate the route correctly. If one acknowledge alert, when YOKOGAWA autopilot is still in "NAVI" mode, then the route steering is automatically terminated and system generates alert "**AP mode Conflict - Use AUTO**".

- Safety Contour Changed

User has to select safety depth suitable for your ship. .

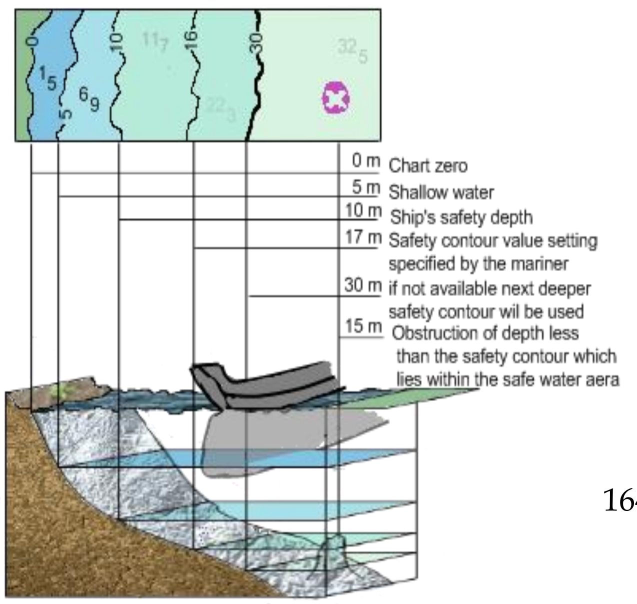
- Sounder Reading

The depth output from a depth sensor (for example, echo sounder) is shown on the Other page in the Sensors dialog box.

20.2: Depth-Related Information

With ENC vector data, relevant depth information can illustratively be displayed and used for safety-related alarms. Safe (navigable) and unsafe (shallow) waters are visually indicated on the display in terms of the following items:

- A ‘Safety Contour’, e.g. the 10m line, which can be selected and high-lighted;
- Several depth contours based on the depth contour intervals contained in the ENC database, e.g. of 2m, 5m, 10m, 20m, 30m, 40m, 200m;
- Depth areas between two depth contours, e.g. ‘between 10m and 20m’ or ‘less than 10m’ which can be displayed in different colours;
- Individual spot soundings which may be indicated as dangerous (black) or safe (grey);
- Special symbols for isolated dangers (wrecks) when the depth at the location is less than the chosen ‘Safety Depth’.



The ‘Safety Contour’ is the boundary between safe and unsafe water. Based on own ship’s draught, the Watch Officer can enter the intended safety values into the system and generate a display showing navigable waters (deep waters) and non-navigable waters (shallows). The depth areas can be discriminated by using:

- Two colours (blue and white) or;
- Four colours (dark blue, light blue, grey-white and white).

In addition to visually displaying the items listed above, the following items can also be used for automatic safety-related alarms taking the draught of own ship into account:

- The safety contour;
- Unsafe depth areas;
- Unsafe spot soundings;
- Individual underwater risks (obstructions, wrecks).

ECDIS performs a continuous check to ensure that these values are not violated (route check and 'Look-ahead'). An indication or alarm is provided independent of the chosen chart scale and regardless if the shallow object to be encountered is shown in the chart section displayed or not.

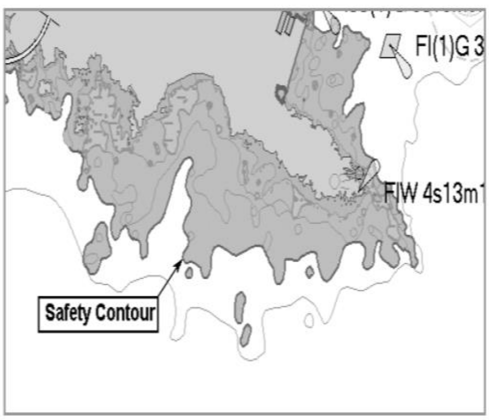
20.3: Depth Indication

An ECDIS using ENC data has a number of ways to help the user identify safe and unsafe depth of water.
It must be remembered that ENC depth data is referenced to a local vertical datum based on a low tide definition. Increasingly for ENCs, this datum is Lowest Astronomical Tide (LAT). The area covered by a particular vertical datum is defined by an S-57 Object Class known as VERDAT. The actual datum in use may therefore appear on the Pick report for any particular position on the chart display, or else within a dedicated 'Chart Properties' facility.
Displayed depth data in the chart area of an ECDIS is nor permitted to be adjusted for tidal height. This is designated to give an additional safety factor but can be inconvenient in some circumstances, particularly for *marginal vessels*, meaning those vessels that need to enter waters that can be at depths less than the draught of the vessel, depending on the state of tide.
There are three standard methods available to the user for highlighting available depth:

- Safety contour
- Safety depth
- Deep and shallow area indication

- **Safety Contour**

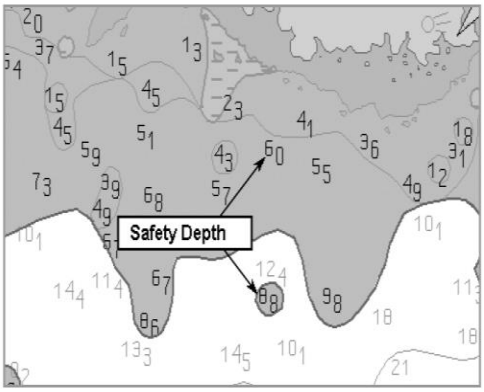
This is a user-entered depth that ideally coincides with the contours available on the ENC cell in use, giving an adequate safety allowance for the actual draught of the vessel. It will be shown on the chart as bold black line and there is a distinctive change in colour of



areas that are shallower and deeper than the safety contour. If there is no contour in the ENC cell that corresponds to the user-input safety contour value, then the next deepest contour will be automatically selected by the ECDIS. If the safety contour in use becomes unavailable due to a change in source data, the safety contour will default to the next deepest contour. In both of these cases an indication to the user will be provided by the ECDIS.

- **Safety Depth**

This is a user-supplied depth that will affect the appearance of spot soundings, if these are selected to be displayed on the ECDIS. On a display configured for daylight viewing, this will appear boldly in black when the spot sounding is less than the safety depth, signifying a potentially unsafe situation. Spot soundings that are more than the safety depth will appear less dominantly in grey, signifying safe depths, providing the safety depth has been appropriately entered



- **Deep and Shallow Area Indication**

One of two schemes can be selected by the user to emphasize deep and shallow areas by the use of colour. The areas are bounded by contours; not by spot soundings. The first scheme uses just two colours – blue and white in daylight and blue and black at night. All areas deeper than the safety contour are shown in white/black (depending on day/night settings); all areas shallower than the safety contour are shown in blue.

The second scheme uses four colours and contains two selectable contours in addition to the safety contour – shallow and deep depth contour. For the day setting, depths less than the shallow depth are shown in deep blue, extending from the drying line to the shallow depth contour; depths between the shallow and safety contour are shown in light blue; depths between the safety contour and deep contour are shown in grey; and depths greater than the deep contour are shown in white.

NOTE: The shallow contour should be used to highlight the gradient of the seabed adjacent to the safety contour and the deep contour to highlight the depth of water in which own ship may experience squat.

Recommended safety settings for ECDIS

Appropriate safety settings are of paramount importance for the safe navigation:

Safety depth :	Normally ship's draft + Squat
Safety Contour :	The division between safe and unsafe water. (Basically Ship's draft + Squat + UKC - Ht of tide
Deep Contour :	To indicate the area in which the depth of water is such that own ship may experience squat. Normally twice vessel's draft.
Shallow Contour :	To highlight the gradient of the seabed adjacent to the safety contour. It should be next contour shallower than Safety Contour.
Underwater obstn / isolated danger :	The display of isolated dangers changes according to the safety contour

LESSON 3: ROUTE PLANNING

Route planning takes place before the voyage begins, except in situations where major changes in the route are called for while the ship is underway. In either case, both ECDIS and ECS will allow the display of the smallest scale charts of the operating area and the selection of waypoints from those charts. ECDIS requires a warning that a chosen route crosses a safety contour or prohibited area; ECS will not necessarily do so. If the data is raster, this function is not possible. Once the waypoints are chosen, they can be saved as a route in a separate file for later reference and output to the autopilot.

It allows the navigator to select route planning as rhumbline or great circle; the software also enables the user to enter the waypoints directly from the great circle route file. If not, they will have to be entered manually.

Except in exceptional circumstances, route planning should not be performed on the primary ECDIS when a route is being monitored. It should be considered a 'back of the bridge' function and normally be completed before commencement of the voyage. If a change to the plan is essential to be implemented during the voyage, it is ideally performed on the back-up equipment. Obviously, the re-planning should not be the duty of the OOW. If the primary ECDIS has to be used, a suitable point in the voyage should be chosen that minimizes the need for immediate chart use for route monitoring. Automatic route-monitoring alerts should continue to be made by the system during planning. However, it is most unlikely to be an appropriate time for re-planning on the primary ECDIS if route-monitoring alerts can be expected. Some systems provide a split screen, allowing route planning activities to be carried out in parallel with monitoring own ship's position. It remains the case that the OOW should not be carrying out the planning activity.

And during route monitoring, ECDIS must show own ship's position whenever the display covers that area. Although the navigator may choose to "look-ahead" while in route monitoring, it should be possible to return to own ship's position with a single operator action. Route monitoring includes a continuous indication of vessel position, course and speed. Additional information that ECDIS can provide includes distance right/left of intended track, time-to-turn, and distance-to-turn, time to "wheel-over" position, and past track history.

A route plan defines the navigation plan from starting point to the final destination. The plan includes:

- Route name
- Name, latitude and longitude of each waypoint
- Radius of turn circle at each waypoint
- Safe channel limits
- Chart alert calculation based on channel limits against chart database and user chart danger
- Minimum and maximum speed for each leg
- The navigation method (rhumbline, great circle)
- Fuel saving
- ETD for the first waypoint
- ETA for the last waypoint
- Ship and environmental condition affecting the ship speed calculation
- Name of the user chart to use during route monitoring together with this planned route
- Name of the Notes to use during route monitoring together with this planned route

Using the above-mentioned data, the system calculates speed, course and length for each leg, ETAs for each waypoint, fuel consumption and WOP for the Autopilot. It also calculates safe water areas based on operator-defined channel limits. The calculated data is displayed in tabular form that can be printed as a documented route plan and also stored in a file for later use. The route files thus formed contain the Autopilot commands for each waypoint.

The main functions of route planning are:

- Define waypoints
- Define turnings for each waypoint
- Define channel limits for each leg (a leg is the line connected between two waypoints). The channel limits are used to detect chart alerts when you are planning or monitoring your route.
- Define the speed for each leg
- Calculation for ETD and ETA
- Calculation for most economical sailing

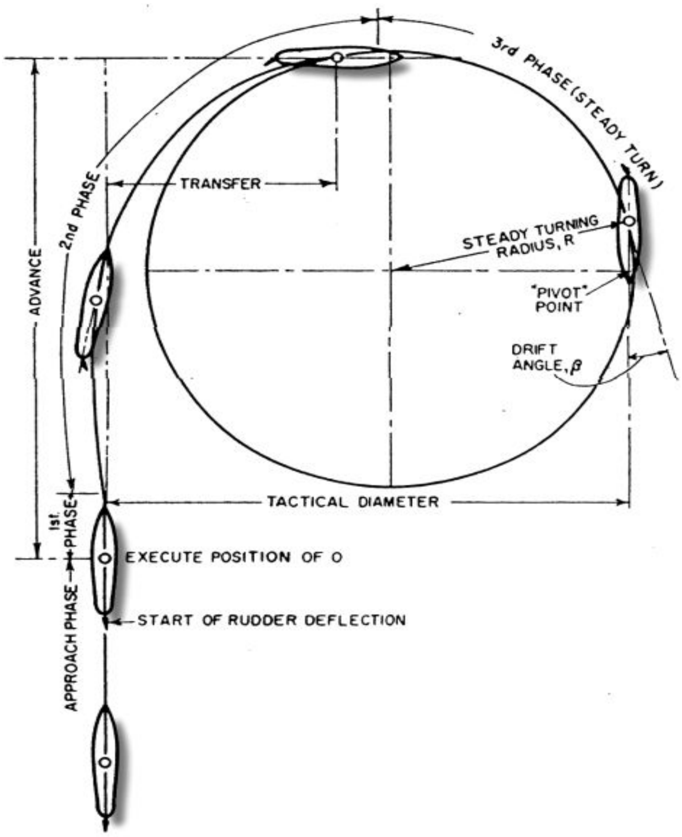
Note: Limitation of displayed route

If you have small scale chart(s) on display having the whole eastern/western (0-180°E/0-180°W) hemisphere and a part of the other hemisphere on display, there is a limitation to display a route. To avoid this, set chart on the center so that the whole eastern/western hemisphere is not on display.

CH. 21: VESSEL MANEUVERING CHARACTERISTICS

21.1: Turning Basics

Turning Circle - A ship's turning circle is the path followed by the ship's pivot point when making a 360 degree turn.
Advance - Advance is the amount of distance run on the original course until the ship steadies on the new course. Advance is measured from the point where the rudder is first put over.
Transfer - Transfer is the amount of distance gained towards the new course (shown here for 90° heading change).
Tactical Diameter - Tactical diameter is the distance gained to the left or right of the original course after a turn of 180° is completed.
Final Diameter - Final diameter is the distance perpendicular to the original course measured from the 180° point through 360° (shown here for steady turning radius, R).



Pivot Point - A ship's pivot point is a point on the centerline about which the ship turns when the rudder is put over.
Drift Angle - Drift angle is an angle at any point on the turning circle between the intersection of the tangent at that point and the ship's keel line.
Rate of Turn - the speed at which a ship, vessel, or unit is turning at, or is capable of turning at, measured in degrees per minute,

(**Reference: *http://web.nps.navy.mil/~me/tsse/TS4001/support/1-11-1.pdf***)

21.2: Own-Ship Setting

To use an ECDIS fully at its design potential, it is essential that certain information concerning own ship is entered into the system. Some of this only needs to be entered once; other information is voyage-related. On many ECDIS equipment certain data can only be input by an authorized engineer, normally when the equipment is commissioned. This can include length, beam, and turning characteristics of the vessel. It may not be possible to check this data directly but, if errors are suspected in use, the Master should be informed, and he or she may decide that correction is required.

21.3: Track Control System

➢ Starting Track Control

The automatic track control starts with a choice of the route to be sailed. In many systems, the starting conditions are the arrival at a position inside a checked and thus safe 'track corridor' which gives the maximum cross-course space left and right from the route, a predetermined difference between the planned track and the steered course (course limit, e.g. <60°), or setting of the direction of turn to enter the planned track.

The occurrence of this conditions is easily recognizable by the user, thanks to the constant display on the chart background of the own ship's position, and of the heading and speed vector in front of it. The automatic track-following normally has two modes of operation:

- Steering of the ship along the planned route leg;
- Steering directly to the next waypoint ahead.

➢ Following a Track Through Track Control

Automatic track control is a control method in which the heading control device (often called 'autopilot') is the actuator. When sailing along a straight track, a second control loop is added to the heading control. Its control procedure serves to determine the course to be steered so the ship holds the planned track or the ship is guided back to the track using the actual cross-track error or the direction to the next waypoint. If necessary, drift will be taken into consideration. The heading controller determines the necessary rudder angle with which the ship can hold the heading needed for the desired course over ground. Track control consists then of three control functionality's each of which is adjusted by its own control parameter:

- Heading control – the heading of the ship is controlled at a required value. The difference between the actual and desired heading is equalized by the appropriate rudder angle;
- Course over ground control – holds the planned course over ground at a required value. The required heading is determined from the difference between the actual and desired course;
- Track control – this function determines the required course over ground from the actual track deviations.

➢ Remote Controlled Track Steering

At the simplest level of this automation technique, the electronic chart serves as a remote operating unit for the heading controller. Within this configuration, the ordered heading is conveyed according to the user input from the electronic chart to the heading controller. The rudder position necessary to steer this heading is there determined and transferred to the rudder installation. Several autopilot systems are capable of determining the course to be steered using the transferred cross-track error values. In these configurations, the electronic chart will transfer only the actual deviations from the track and the heading controller generates the required heading values to be interpreted by appropriate rudder commands in order to keep the vessel on the intended track.

21.4: Track Monitoring

Presentation of the own ship position, actual cross-track error and of the past track on the electronic chart provides an optimal monitoring of the automatic track control process. The approach to a waypoint and the imminent change of course is also easily recognizable on the electronic chart, thanks to its geographical presentation. The user is warned by an alarm when the ship leaves the track corridor or is within the preset time from commencing a change of course ‘wheel-over point (WOP)’ and ‘wheel-over line (WOL)’. The execution of the change of course is made possible through transfer from the electronic chart to the autopilot of the previously entered turn radius or of the rate of turn that can be held at the actual speed. After the transfer in such a way of a start signal that may contain the course to be steered on the next leg, the maneuver which started at the WOP or WOL is carried out. The controlling quantity for the autopilot on the curved track is the predetermined rate of turn. A second variant is to continually determine the new course to be steered during the course change, relating to the track curvature and to the actual deviation from this track.

Despite the apparently unambiguous combination of chart image and continuous display of the own ship’s position, the system is not free of problems. For instance, there are errors that can be introduced by the position finding system.

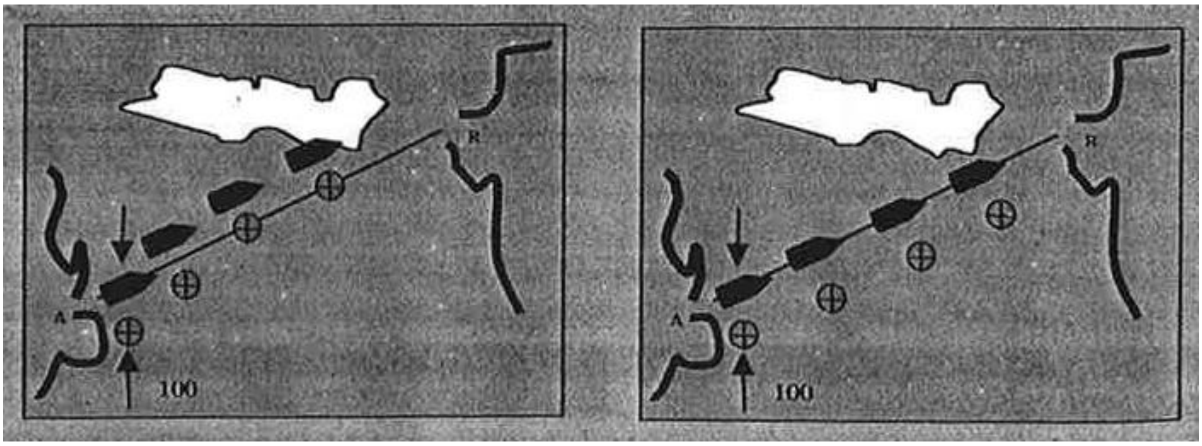


Fig. 21.1: Automatic track control with GPS support only (left) and with GPS and radar or other monitoring means (right).

The actual position, usually taken from an Electronic Position Fixing System (EPFS) receiver like GPS or future Galileo is evaluated in the route following as a controlling quantity. Fig 21.1 shows a chart display with a ship at the correct (!) position A. Let as assume that the position receiver determines at that time the position which is 100m south of the real ship. The track controller will steer the ship so as bring its position onto the planned route and therefore will lead the ship on a parallel track 100m North of the planned one, over the shallows. Despite that, the symbol of the actual ship position will be always and under all conditions shown on the chart image on the desired planned route (see Fig. 21.1 left (above)) and will falsely offer security, where none exists. Naturally, the danger would be much less when using DGPD or GPS after withdrawal of SA (Selective Availability), since then the ship should be no more than 3 to 10 meters from its planned route.

The danger is reduced also by overlaying the chart and radar images. Only when the chart and radar symbols for the appropriate object coincide, and the GPS derived symbol follows the track under these circumstances can the strived for security be ascertained. In the case in question however, the position fix symbol will pass 100m South of the planned track (see Fig. 21.1 right (above)), the automatic track control will be turned off and the ship must be led using the conventional means of radar location.

21.5: Speed Monitoring

Many integrated navigation systems containing electronic charts as a core component offer the user access to a range of actual values of speed over ground, distances towards destination and the remaining time to go during the voyage. An automatic speed over ground control system, which adapts the ships propulsion to the ordered speed, or to reach the destination on a predefined date can be built on this basis. The controls for this – at the moment of growing use on ships operating on ferry routes – can be likewise integrated in the user interface of the electronic chart.

21.6: Track Keeping Autopilot

The ECDIS may provide the track information and certain levels of control for the autopilot. And when using the autopilot, the following cautions should be observed:

- Take care that the ship is close to the desired track and that there are no possibilities of conflicts with any other vessel when the equipment is engaged.
- Ensure that the position-fix system is automatically and continuously monitored by a second independent position source. This is an IMO requirement. An alarm will be given if there is a discrepancy beyond a user preset limit. A back-up navigator alarm will be given if not acknowledged by the OOW within 30 seconds.
- When the wheel-over indication is given, be prepared to switch the system to manual if the change of course is inappropriate. The indication need only be given one minute before the actual wheel-over.
- An alarm will be given at wheel-over, which should be confirmed within 30 seconds, otherwise the back-up navigator alarm will be initiated.

- Alarms for cross-track error, course difference and low speed will be generated automatically but limits at appropriate values need to be preset by the user.

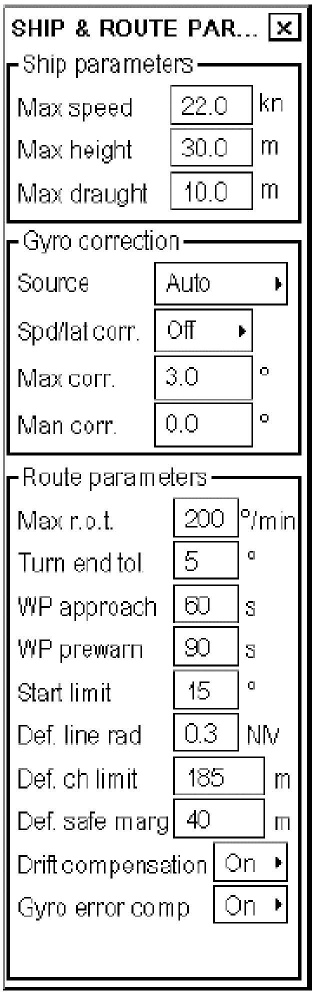
Great care must be taken when in automatic track-keeping mode to ensure that positional integrity is being checked at regular intervals, perhaps at every ten minutes during a typical coastal voyage. This is because the autopilot and the ECDIS will be relying on the same positional data and so the display of the ship's position will inevitably appear overlaying the planned track on the ECDIS display, even if there is a gross positional error. This tends to give a false sense of security, stressing the need for regular independent integrity checks.

Navigation Parameters Setting
The purpose of navigation parameters is set the basic parameters for the ship. These parameters are relative to ship steering and they are very important to get correct function of the integrated navigation system. They must be maintained carefully. Modification requires a good knowledge of the parameters' importance.
In order to edit Ship and Route parameters, do the following:

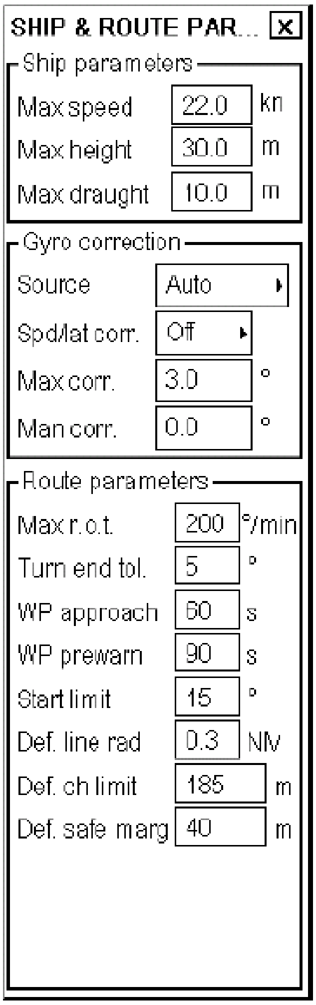
1. Place the cursor on the text SINGLE, PLAN, SLAVE, MULTI or MASTER (whichever is shown) on the lower right corner, then push the right mouse button to open the Initial Settings dialog box.
2. Select Navigation parameters then push the scrollwheel.
3. Select Ship and Route parameters from the menu then push the scrollwheel.

SHIP PARAMETERS

MAX speed: Maximum speed the ship can do.
MAX height: Max. height of ship above sea level.
MAX draught: Max. draught of ship.
GYRO correction:
Source: Select method of gyro error correction, auto, manual or off.
SPD/LAT CORR.: Select On or Off
MAX CORR.: enter max. value for correction
MAN CORR.: enter value for manual gyro correction.



When using FURUNO FAP-2000 or YOKO-GAWA PT-500A



When using TOKYO KEIKI PR-6000

ROUTE PARAMETERS

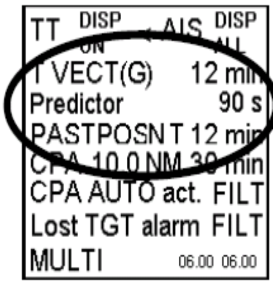
MAX ROT: Indicates the maximum rate of turn of the ship.
Turn end tol: This defines the window for the detection of the end of turn. Typical values are between 2 to 4 degrees.
WPT approach: Set the alert time before approaching the wheel over point.
WPT prewarn: Set the alert time before approaching the wheel over point. It should be well in advance of the WPT approach alert time.
Start limit: Set the maximum approach angle against planned course in order to accept start of automatic route steering.
Def. line RAD: Used to define the default value of radius between waypoints during automatic route steering.
Drift compensation: Enables/disables the drift compensation during automatic route steering.

GYRO error: Enables/disables the gyro error compensation of set course during automatic route steering.

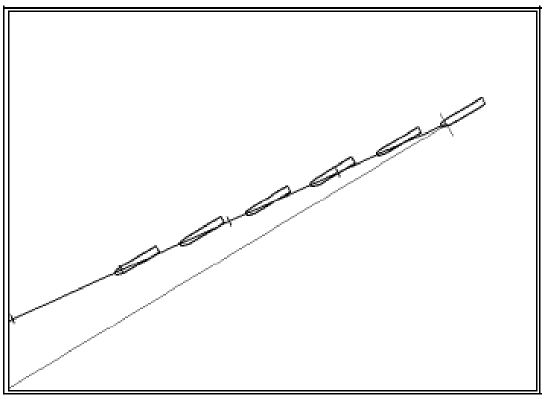
21.7: Using the Predictor

The Predictor is a tool for estimating own ship's future positions and behavior. The time from current position to the last of the predicted position may be selected by the between 30 and 180 seconds, in 30 second intervals. The on-screen Predictor graphic consists of five pieces of own ships drawn in true scale to successive future positions.

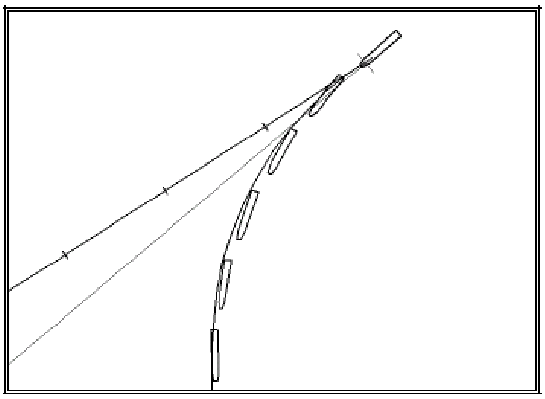
The predictor is calculated using current:
• Docking speed components:
- Transversal bow speed
- Transversal stern speed
- Longitudinal center speed
- Rate of turn



These components are assumed to be stable during the prediction period.
The predictor can be used in every steering-state, even when steering without the Trackpilot.



Predictor shows drift



Predictor in a turn

Note: An ECDIS curved predictor may only project a momentary rate of turn, rather than sophisticated hydrodynamic calculations, and therefore have limited accuracy.

CH. 22: ROUTE PLANNING BY TABLE AND CHART

Route planning is an onerous and exacting task, whether carried out with the use of paper charts or ECDIS. It is considered here to be part of voyage planning, and all OOWs should be fully familiar with IMO's Guidelines for Voyage Planning. These are equally applicable when using paper charts. Moreover, ECDIS provides many benefits for route planning.

- For instance, electronic charts are quick and easy to select

- Rroutes and any modifications do not have to be manually transferred from chart to chart; and it is easy to ensure that all charts are updated
- In addition, measurements and calculations can be much easier as they often involve automated facilities, simply accessed from the cursor and the entry of any additional data from the keyboard.

However, ensuring a safe planned route requires experience, time and good familiarity with the general principles of ECDIS and its implementation on a particular ship. ECDIS provides automatic route checking facilities, which are useful but should never be used in place of diligent manual checking procedures. The planned route must always be meticulously checked manually. Good familiarization training can provide the knowledge to be able to carry these out on any particular installation.

Presumably, route planning takes place before the voyage begins, except in situations where major changes in the route are called for while the ship is underway. In either case, both ECDIS and ECS will allow the display of the smallest scale charts of the operating area and the selection of waypoints from those charts. ECDIS requires a warning that a chosen route crosses a safety contour or prohibited area; ECS will not necessarily do so. If the data is raster, this function is not possible. Once the waypoints are chosen, they can be saved as a route in a separate file for later reference and output to the autopilot.

It is a good idea to zoom in on each waypoint if the chart scale from which it is selected is very small, so that the navigational picture in the area can be seen at a reasonable scale. Also, if a great circle route is involved, the software may be able to enter the waypoints directly from the great circle route file. If not, they will have to be entered by hand.

22.1: Preliminary Tasks

There are a number of preliminary tasks that have to be undertaken before a route can be planned on ECDIS. Firstly, it is essential that the planner has read and fully understood all the requirements on voyage and route planning detailed within the Bridge instructions. It is also essential that voyage specific requirements, laid down by the company, the charterer and the Master are fully understood.

All planning information relevant to the voyage must be gathered together. This will commonly be a mixture of digital and paper-based information and may require certain knowledge and details to be collected from appropriate personnel on board or ashore; the latter possibly by use of phone, SMS or email. The information needed will include but may not be limited to:

- The condition and state of vessel, its stability and its equipment
- Ship dimensions, draught and maneuvering characteristic data
- ENC data at the appropriate scale relevant for the voyage, supplemented by RNC and/or paper chart data when appropriate ENCs are not available.

- The latest ENC and RNC updates on disk or electronically through a telecommunications service
- If RNCs are to be used, a set of updated paper charts meeting the defined Appropriate Portfolio of Paper Charts (APC)
- Notices to Mariners – Weekly Editions and summaries
- Accurate and up-to-date sailing directions and pilot books
- Up-to-date port information, which may be best accessed by use of the internet, if available
- Details of relevant shore-based emergency response arrangements
- List of Lights and Fog Signals, to be used where equivalent ENC data is not available
- List of Radio Signals
- Tide tables for relevant areas in digital or in paper form
- Tidal stream atlases and/or tidal stream MIOs for ECDIS
- The latest Maritime Safety Information for the route, which can generally be obtained by NAVTEX for local coastal areas and SafetyNet for non-coastal regions
- Ships' routeing guides
- Estimates of the volume of traffic likely to be encountered
- Ocean passage guides
- Waypoint lists
- Weather and climatic data, including weather routeing plans
- Radio signal information
- Information relating to pilotage, including, if appropriate, embarkation and disembarkation points
- Load line requirements

It is essential to check that all information used is up-to-date. Any doubts on this should be resolved before the voyage commences or, if not fully possible at the planning stage, well before entering the area of concern. In particular, a check is needed that all relevant ENCs and RNCs are fully updated before commencing route planning, although this does not preclude later updates being applied as they become available. Facilities will be given to plan one or more alternative routes. The ECDIS will ensure that the selected route will be distinguishable from the alternative routes and this difference in display needs to be understood by the user.

The directory of charts loaded on ECDIS will be visible to the user probably as a list and as a graphical display, the latter probably using an outline chart of the world for its background, which can be zoomed and scrolled to show the appropriate detail. On some systems this may be performed on an ancillary program rather than in the ECDIS software itself.

22.2: Tabulated Route Plan

Once the planner is satisfied that the route has been appropriately set, more detailed data can be added to the plan, using the display option showing it in tabular form. In general, systems allow both the tabulated plan and a user-set chart area to be viewed simultaneously. The conventions used in displaying the plan should be understood. They are often listed by waypoint number and the leg information assigned to the waypoint is that from the previous waypoint to the listed waypoint.

Typical entries include:

1. **Waypoint number**: it is likely that the ECDIS will automatically assign these as consecutive numbers and therefore any additions or deletions of waypoints will lead to an automatically renumbered list.

2. **Waypoint name:** these will need to be user-entered unless they are contained in a transferred data file along with the lat/long coordinates of waypoints. Transfer from a previous planned route is normally possible. On some systems, the user may be given an opportunity to enter the name of the waypoint when fixing the waypoint position on the chart display.

3. **Waypoint Coordinates:** normally entered from the cursor position on the chart during planning.

4. **Leg course and length:** automatically calculated by the ECDIS. If the leg is a great circle which has not been broken down into rhumb line segments, there will normally be no course entry. If there is an entry for this case, its meaning should be explained in the user manual; it usually denotes the initial course. Cumulative distance to the waypoint may also be tabulated.

5. **Speed:** the planned speed for the leg, which will always be at or below the safe speed after considering the proximity of navigational hazards along the route, the depth of water and the maneuvering characteristics of the vessel. The entered speed will be used for timing calculations, including ETA and for calculations concerning turns.

6. **Turn Information:** This can usually be entered by rate of turn or by radius. The system will normally calculate one from the other one, and display both the parameters using the planned speed for the leg. It may also be possible to insert Wheel-over points (WO).

7. **Date and Time:** for planned time of arrival at way points. This data will be calculated from the input speed for each leg and the automatically determined distance. Probably cumulative time will also be calculated.

There are likely to be facilities for additional data to be tabulated, which should be determined from the user manual. In particular, on many systems the safe channel width for each leg can be input into tabulation.

In general, the speed entered by the planner should compensate for any tidal stream or current effects and, therefore, be Speed over Ground. In principle, a sophisticated

ECDIS with access to current flow data could determine these automatically, allowing planned speed through water to be input.

Route Planning Functions

Planning a route from point A to point B is very simple on an electronic chart. The first step is to display the areas necessary for the intended route at a desired scale. The route plan is then created by entering ‘waypoints’ – graphically rather than alpha-numerically. After the entire route is created, it should be displayed and safety-checked, and finally saved for later implementation in the ECDIS as a ‘route plan’.

The ECDIS Performance Standards require the capability to create plans using straight and curved line segments. In the latter case, curves (of controlled or constant radius) between straight legs are created in order to achieve realistic behavior of a maneuvering ship. Also, great-circle routes may be created by curved line segments.

Waypoint Data and Waypoint List

Besides the position, individual waypoints of the route are given ‘way point data’: an identification (by name or number) and, if necessary, the turning radius and the alert time before wheel-over. Similarly, the legs are given ‘leg data’: information on the planned speed, the maximum cross track limit and whether the voyage takes place along the great circle or along the rhumbline. The waypoint list can be modified in graphic mode (cursor) and also in alpha-numeric editing mode (using the ‘copy’, ‘delete’ and ‘paste’ keys). Waypoints and routes can be saved in a route library and reused in the future. On many ships, the waypoint list can also be printed.

Waypoints and Routes

In a route planning mode, ECDIS will allow the entry of waypoints as coordinates of latitude and longitude, or the selection of waypoints by moving a cursor around on the charts. It will allow the creation and storage of numerous pre-planned routes, which can be combined in various ways to create complex voyages. For example, one might define a route from the inner harbor to the outer harbor of a major port, a route for each of two or more channels to the sea, and several more for open sea routes to different destinations. These can then be combined in different ways to create comprehensive routes that will comprise entire dock-to-dock voyages. They may also be run in reverse for the return trip.

1. **Definitions**

   A ROUTE is a sequence of waypoints defining a passage. Each route is assigned a unique name. Each waypoint in a route represents a change of course that takes place in a fixed radius turn. The beginning and end points of the turn are called turn-points. The straight line between two turn-points is called a leg.

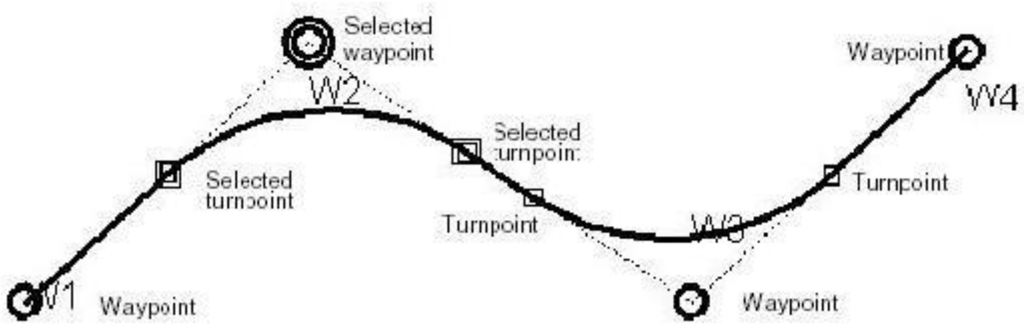


Fig. 22.1: Route with waypoint, turnpoints and legs

A set of parameters are used to specify each waypoint and the following leg. The parameters are:

- **Name** : Waypoint name (manually entered).
- **Lat** : Latitude (manually entered).
- **Lon** : Longitude (manually entered).
- **Leg** : Rhumbline (RHL) or Great Circle (GC) (manually entered).
- **Spd** : Speed (manually entered).
- **Wait** : Delay at waypoint (manually entered).
- **Radius** : Turn Radius (manually entered).
- **Offtrack** : Off track limit (manually entered).
- **Max** : Maximum speed (manually entered).
- **Message** : Message associated with waypoint (manually entered).

The following parameters are computed by the system:

- **W** : Waypoint number.
- **CRS** : Course Over Ground.
- **Dist.** : Length of leg.
- **TDist** : Distance from the start of route to a waypoint.
- **RDist** : Distance from a waypoint to the end of a route.
- **ETA** : Estimated Time of Arrival at the waypoint.
- **Rtime** : Remaining Time, estimated time to reach the end of the route.

2. Validating Routes

To validate a route is to check if the route crosses own ship's safety contour or the route crosses the boundary of a prohibited or a geographic area where special conditions exist.

- Validation is always done on the best charts available.
- Routes to be validated are not allowed to have inconsistent geometry that means that there must be space for a straight leg segment between waypoint turns. Correct this prior to validation.
- Validation results are added to the route as validation status information.
- Grounding and warning information can be studied in detail in the list box.
- Validation can take place in four modes:
    - Validation is always done on the best charts available.

- Routes to be validated are not allowed to have inconsistent geometry that means that there must be space for a straight leg segment between waypoint turns. Correct this prior to validation.
- Validation results are added to the route as validation status information.
- Grounding and warning information can be studied in detail in the list box.

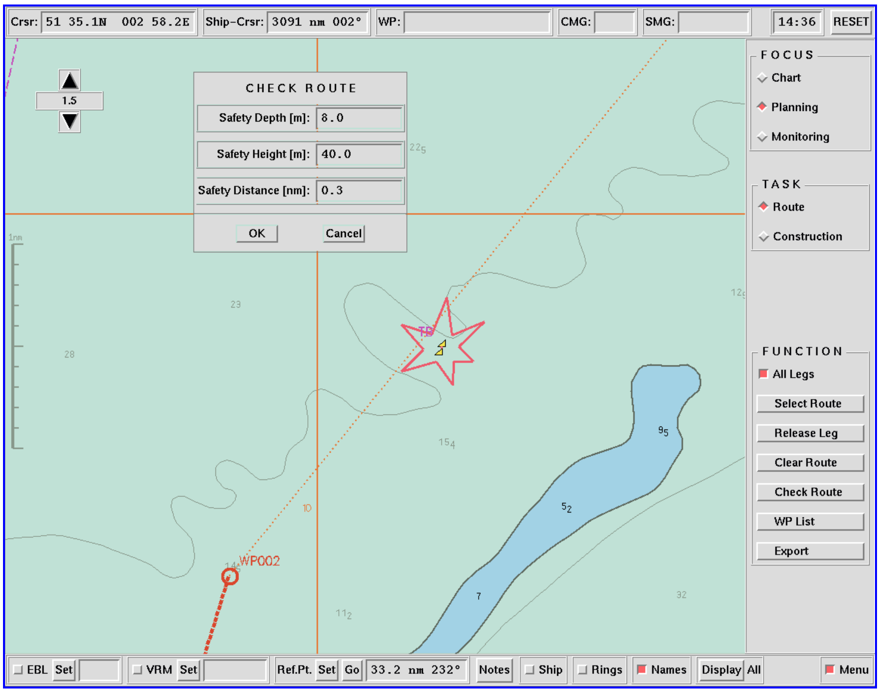


Fig. 22.2: Shows such a case of violating minimum distance

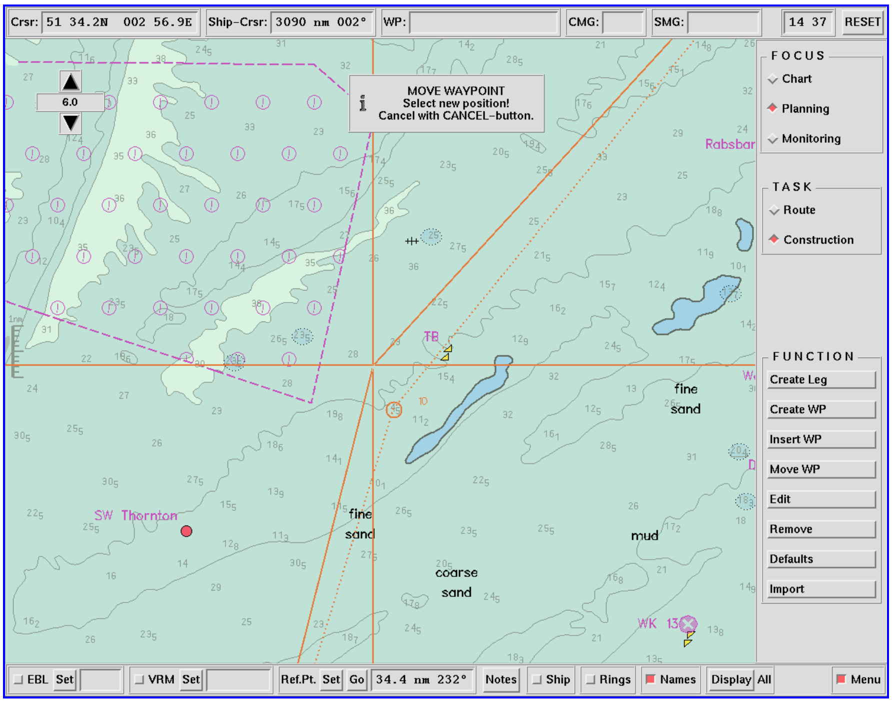


Fig. 22.3: The route is corrected

Validation Code	Description
Bad	Bad geometry - not possible to validate
Not	Not validated
E	ENC charts used for validation
N	Non ENC charts used for validation
M	Manual validation
O	Outside Charts - No chart coverage
G	Grounding
W	Warning - Caution areas etc.

Table 22.4: Codes used in Validation Status

3. Creating Critical Point in the Chart

Critical points are operator defined messages placed along the route. When reaching, or at a set time before reaching a critical point the system gives an alarm. Critical points can be defined in two ways; directly on the chart or through the menu system. Reaching a critical waypoint means passing abeam of it.

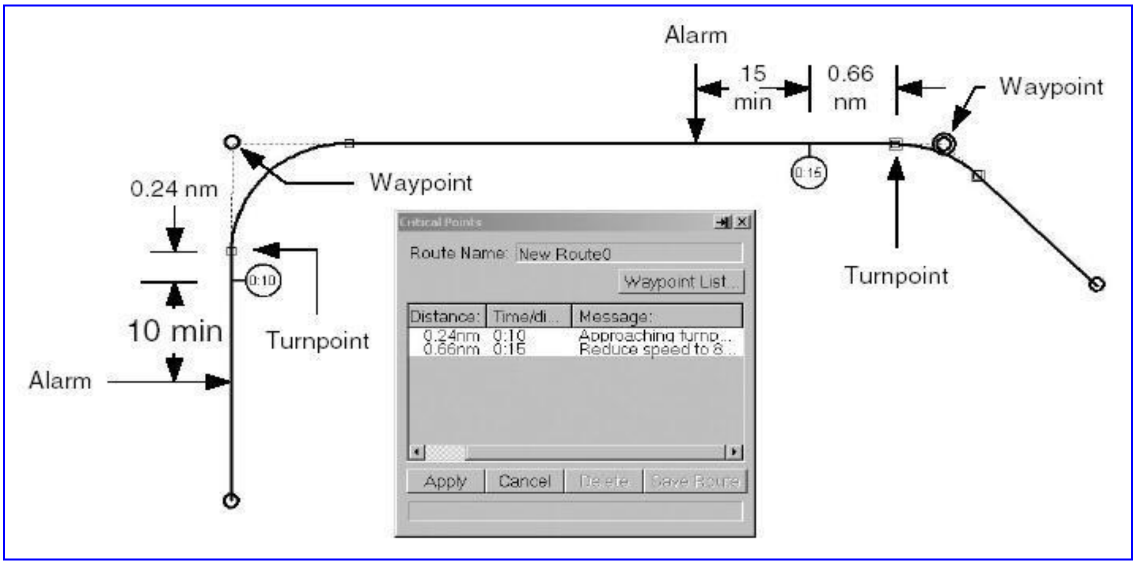


Figure 3.5: An illustration of critical points and critical points menu

22.3: Retrieving a Stored Route Plan

Choosing Route to Monitor
Just select the file name that you created and it can be monitored if route validation or check was carried out.

22.4: Modifying an Existing Route

➢ **Parameters**
Main parameters for the route planning are:
- Latitude and longitude of the waypoint
- Channel limits to the waypoint
- Turning radius of the waypoint
- Maximum and minimum speed limit for a leg

➢ **Changing Waypoint Position**
To change position of a waypoint you have following alternatives:
- Enter latitude and longitude on the WP page in the Plan Route dialog box.
- Enter distance and direction for next waypoint.
- Drag and drop waypoint using the left mouse button.
-

➢ **Entering Latitude and Longitude in Position Field**

➢ **Entering Distance and Direction for Next Waypoint**

➢ **Dragging and Dropping Waypoint to New Position**

➢ **Changing Other Waypoint Data**
Data’s can be change such as waypoint, such as name, steering mode, turning radius, min/max speed.

➢ **Adding a New Waypoint at the End of a Route**

➢ **Adding a new waypoint by using the left mouse button.**

➢ **Adding a new waypoint by the Next WP button.**

22.5: Using the Alarms/Alerts Page

The Alarms/Alerts Page lets you define conditions along a route for which you want to be alerted, by visual or audible indication

22.6: Using the Check Page

The Check Page allows you to make safe water calculation for your route. You also store the names of the user chart and pilot data to use during route monitoring together with planned route on this page.

22.7: Using the Parameters Page

The Parameter Page allows you to set departure time and arrival time for your route. Also optimization type is chosen in this page. It also gives details of the planned estimated time of departure from point of origin and the estimated time of arrival to its destination both in UTC and the corresponding speed limit for a route.

22.8: Detailing and Checking the Route

There are a number of planning tools on ECDIS that help with the detailing of the route. For instance, once the largest-scale charts are in use, it may be beneficial to plan certain legs to align with visual and/or radar-prominent ground-fixed charted features. These can then be used to act as pilotage aids when executing the route. When the planner is satisfied that the route appears to be safe, including taking into account all items listed in the ‘Preliminary Tasks’ and other relevant information, but before inserting details such as turn criteria, and adding pilotage data, such as clearing ranges and bearings, it should be given a first pass by the automatic checking facilities of ECDIS.

To use the automatic checking facility it is necessary to ensure that at least the following safety limits have been correctly inserted:

- Safety contour
- Safety depth
- Safety height (if available)
- Safe passing distance of charted hazards.

The planner must understand the vertical Chart Datum on all charts used in the planning process. This becomes critical if parts of the passage can only be completed at certain stages of the tide or if the ship’s draught is approaching the safety contour or depth. In some cases tidal height can be lower than the charted vertical datum. It should also be remembered that predicted tidal heights are only an average and that particular meteorological conditions can have a major effect on the actually experienced depth of water.

The user manual will detail how the automatic route planning function is used. Use of this function will indicate if the route has been planned across an own ship’s safety contour. It will also check to see whether the route passes closer than the user-specified safe passing distance of the following geographical areas for special conditions exist:

- Traffic separation zone

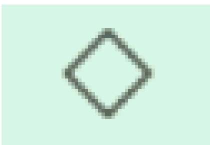
- Inshore traffic zone
- Restricted area
- Caution area
- Offshore production area
- Areas to be avoided
- User-defined areas to be avoided
- Military practice area
- Seaplane landing area
- Submarine transit lane
- Anchorage area
- Marine farm/aquaculture
- Particular Sensitive Sea Area (PSSA)

Indications may be available as a list but will probably, and most usefully, be available graphically, such that potentially problematic objects are highlighted on the chart display. It is essential that the planner fully understand the reasons for each indication given, as it may necessitate certain portions of the route to be modified. The planner must make sure that there is no confusion with similar indications given for different hazards on the same route segments. Manu users complain that this facility provides too many warnings and indications to be useful. This could be because the user-specified safe passing distance has been inappropriately specified.

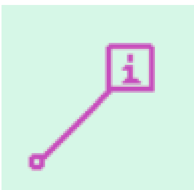
22.9: Sailing Directions, Tidal Tables, etc., Features of Vector Charts (S57)

Vector Charts (S57) contain sailing directions, tidal tables and other textual and picture information which is not immediately visible on the Chart. This information forms an integral part of the legal ENC chart which can fulfill SOLAS requirements and thus replace a paper chart.

Because these features are not permanently visible on the chart as they used to be in case of a paper chart, the ECDIS has special symbols to highlight the locations from which you can use the Info request to know additional information about the above-mentioned features. Below are examples of these symbols.



A Grey box is used to show that Tidal Information is available for Info request by cursor pick.
Note: The visibility of the Grey box symbol is controlled by the item "Depth Contours, Magnetics, Currents" in the Other 1 page of the Chart Display Dialog box.



A Magenta-colored symbol is used to show that additional textual or picture information such as sailing directions are available from info request by cursor pick.
Note: The visibility of the magenta symbol is controlled by the item "Additional Information Available"

CH. 23: TRACK LIMITS

ECDIS, except in RCDS Mode, will automatically check that own ship will not be encountering charted features that are a hazard to navigation. In route monitoring mode, this is always turned on. In route planning mode, the ECDIS can be instructed to check the route automatically. In effect it can be imagined that there is a defined volume around the ship such that if this volume is likely to encounter a hazard, an alert will be given. The minimum requirement for this, as specified by IMO for ECDIS, is the following:

- ECDIS should give an alarm if, within a specified time set by the mariner, own ship will cross the safety contour
- ECDIS should give an alarm or indication, as selected by the mariner, if within a specified time set by the mariner, own ship will cross the boundary of a prohibited area or of a geographical area for which special conditions exist
- An alarm should be given when the specified cross track limit for deviation from the planned route is exceeded
- 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 or rock) that is shallower than the mariner’s safety contour or an aid-to-navigation

When route planning, the ECDIS calculates alarms using user defined off track or channel limits for the route selected. Danger areas within the channel limits are shaded red if the safety contour or selected danger areas are crossed. Once a plan has been completed, it can be verified using the system’s “check page”, which helps the user to identify the legs of a plan where the safety contour has been crossed and where defined danger areas are located. A plan does not have to be free of warnings or alarms to allow it to be saved and monitored.

On route monitoring, an audible alarm activates to warn user when a vessel moves outside the channel limits and when nearing a waypoint. When a ship is going to cross the safety contour set on the display, which can be differ from the safety contour alarm setting used when planning an audible alarm is also activated. To enable this alarm, a watch vector (time and angle) must be defined by the user. If a watch vector is not defined, the safety contour alarm will not activate.

All alerts will be generated from the relevant chart at the largest available scale, whatever chart is being displayed on the ECDIS.

ECDIS manufacturers often meet the requirements by allowing users to specify a safety domain for the vessel, effectively contained by the following parameters:

- In depth, by the safety contour and safety depth
- In forward extent, by the *look-ahead time or look-ahead range*
- In lateral closeness, (best considered as a safe channel width or off-track limit), by a specified distance.

These parameters are graphically shown in Figure 23.1 (below).

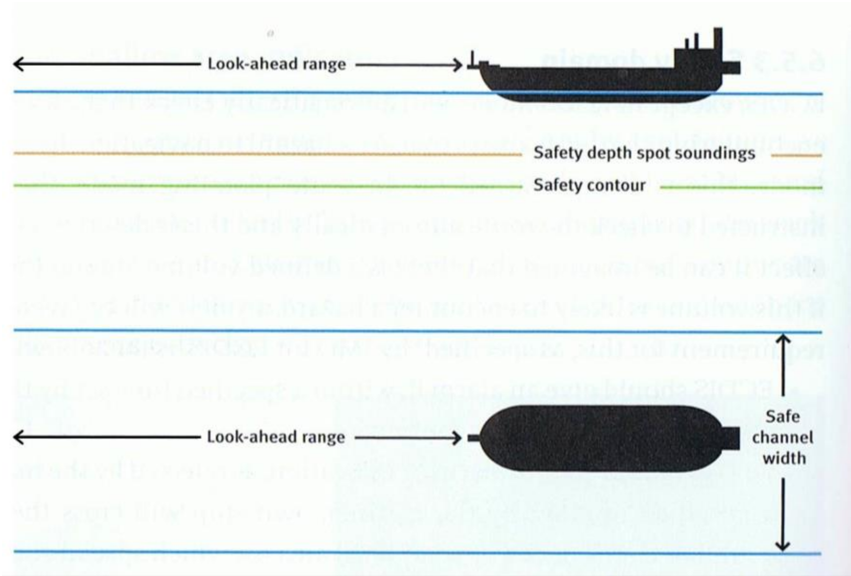


Fig. 23.1: ECDIS safety domain

Particular ECDIS equipment may give some extra sophistication to this general model of a safety domain. In particular, the safe channel width is often able to be entered during route planning for each leg of the route.

Note: *Track Limits or Channel Limits can be edited from the Route Planning Page*

23.1: 'Look ahead': ENC-related Alarms

The look-ahead time or range is an operator-specified parameter, which sets the value in time or distance when an alert is given during route monitoring. Whether the alert is an alarm or indication is dependent on the nature of the circumstances. It is important that this time or distance is carefully set to meet the particular circumstances. If it is set too long, it will create numerous alerts that may be distracting to the operator. If too short, it will not provide timely warnings of potential hazards, which could be outside the displayed area of the chart, but when using a large scale chart, may be relatively close.

Using ECDIS with vector data, the powerful 'Look-ahead' function may be used as 'Anti-grounding' function. The function determines if any charted danger of stranding or a too close approach to an obstacle is registered as lying ahead of the ship's current position. For this purpose, a monitoring zone moves with the ship and raises an alarm when any ENC object which is determined by the system to be dangerous appears within it.

In particular, ECDIS will raise a 'Look-ahead' alarm or warning indication if the ship is to:

- cross a safety contour;
- cross the boundary of a prohibited area or of an area which special conditions exist;
- Pass too close to an ENC object within a look-ahead time pre-set by the Watch Officer. The look-ahead safety parameters are entered by a dialogue window. The safety zone may, for example, have the shape of a circular sector the dimensions of which are determined by the ship's speed and by the preset safety values. Its color is conspicuous.

23.2: Guard Zone

The GUARD ZONE (also known as Safety Frame) provides the user with an advance warning of dangers/cautions. The user sets the dimensions of this guard zone which must be altered according to the prevailing circumstances to prevent unnecessary alarms or to give adequate warning. The navigators need to remember that not all dangers are enclosed by a contour and guard zone remains active even if it is not selected to display on the screen. In order for the alarm system to be properly effective (when the route is being monitored) the own ship's guard zone must be set in a seamanlike manner, i.e. with a sensible time or range warning depending on proximity to hazards and planned speed etc. It is recommended to set the guard zone "As large as possible as the circumstances allow".

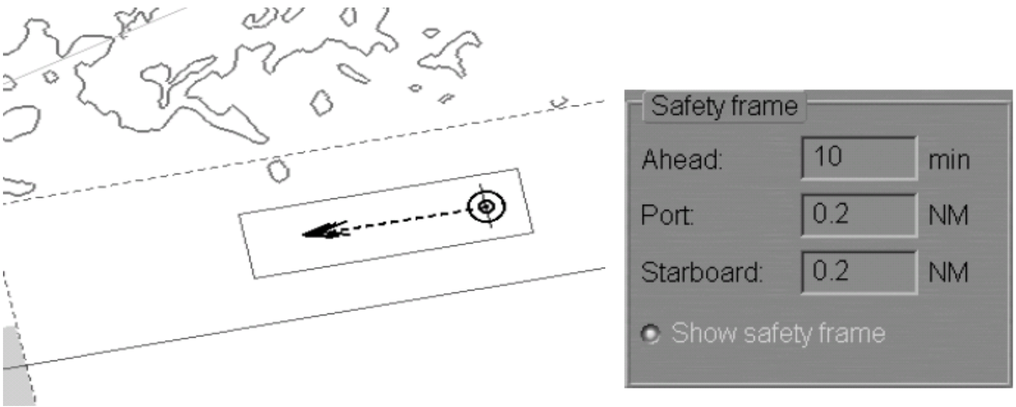


Figure 23.2: Showing Safety Frame Parameter and Symbol

The check of charts consists in the search for the objects identified as a danger to navigation. For the alarm to be generated at the time when the danger to navigation turns up within the Safety frame, as well as when it crosses safety contour or area type objects, the largest scale charts available under the ship position are used.

NOTE:
(Different manufacturers use different procedures and names, e.g., 'Guard Zone', 'Safety Frame', 'Watch-dog' or 'Look-ahead' features; however, they have similar operation and serve the same function.)

CH. 24: CHECKING PLAN FOR SAFETY

Once a route has been detailed and deemed to be satisfactory by the planner it is necessary to run the automatic safety checking facility a further time. There may be several levels of safety check. This should generally be set to the most detailed setting. It is likely to check many aspects not covered by the IMO minimum standards for ECDIS, including that the route geometry is applicable to the vessel, for instance is the turn radius consistent with the actual leg length. If any changes are made, whether to address a safety or a geometry issue or even a modification unconnected with the automatic checking process, a rerun of the latter needs to be performed.

In many instances it is appropriate to plan alternate routes or segments, perhaps to take into account the actual weather or tidal conditions that are prevailing at the time of transiting a particular area or to put in place contingency plans for alternative action in the event of any emergency. The alternates can be saved in conjunction with the primary route and will be shown in route monitoring mode with different symbology. The user manual will describe this process. Good use of the Mariner's Notes facility should be used to provide appropriate annotation.

The Bridge Instructions should then be followed to ensure that the planned route and any alternatives have been appropriately checked and approved. The finally approved route should then be appropriately saved and also copied to the back-up system. This will be a highly manual process if the back-up is paper charts but there will be varying levels of automation for other back-up solutions, depending on their interconnectivity and compatibility. A check should be made on the back-up system that all relevant charts and their updates have been loaded and that the entire route can be viewed on the largest scale charts available.

24.1: Parameter Setting for 'Route Check'

After the visual inspection of the route in various scales and before departure, the selected route must be checked to determine if it can be safely navigated, i.e. if there are any known or charted dangers. The ECDIS function of 'Route check' checks the route for navigational risks. When performing the 'Route check', the ECDIS compares the relevant attributes of all relevant objects along the planned route – as potential risks – with data required for own ship's safe navigation. For this purpose, the Watch Officer sets limits for certain 'Safety values'.
The most relevant parameters are:

- 'Safety draught' (to pass shallow waters);
- 'Safety height' (to pass bridges);
- 'Safety distance' (to pass within horizontal tolerance);
- Planned speed and way-point-radius.

  The values are specific for each individual ship and each route. They are selected according to the ship's characteristics (dimensions, draught) and the sea area characteristics (depth of available safe water, fairway dimensions). If any of these limits are exceeded during the route check, a message is produced.

24.2: Route Check and Route Correction

If the conduct of the 'Route check' reveals dangerous objects which exceed the set safety criteria, it will provide a warning report. This may be a 'Message window' containing a list of relevant SENC objects, verifying that the planned route does, for example:

- Cross a shallow 'Depth contour';
- Transit less than an chosen safety distance from a buoy or other obstruction;
- Cross the limits of an area where special conditions exist (traffic separation schemes, etc.);
- Go under a bridge of insufficient height.

In addition, the automatic route check graphically highlights any 'dangerous' objects on the chart, e.g. by a red star, a red line or a red area, respectively.
The internal 'Route check' is conducted independently of the actual scale used by the Mariner. However, it is recommended to always use the largest scale of the chart display because discovered infringements may not be displayed otherwise. If the 'Route check' detects any planning mistakes, the route must be corrected until all the foreseeable dangers are avoided. The automatic 'Route check' is one of the functions by which electronic charts significantly improve the safety of navigation. It is an essential part of route planning. Only object-based vector data have the ability to recognize the dangers along the route, RCDS data do not.

Route Check
The system will calculate chart alerts using operator-defined channel limit for routes. Danger areas are shown highlighted if safety contour or operator-selected chart alert areas are crossed by the planned route. For more information on route planning, see the chapter on route planning.

Note: If your voyage is going to take a long time or you are planning it much earlier than it is to take place, use display and approve dates corresponding to the dates you are going to sail.

24.3: Activating Own Ship Check

Calculation of your ship predicted movement area is done using watch sector from your ship's position. Sector size is defined by time and Width or by distance and Width

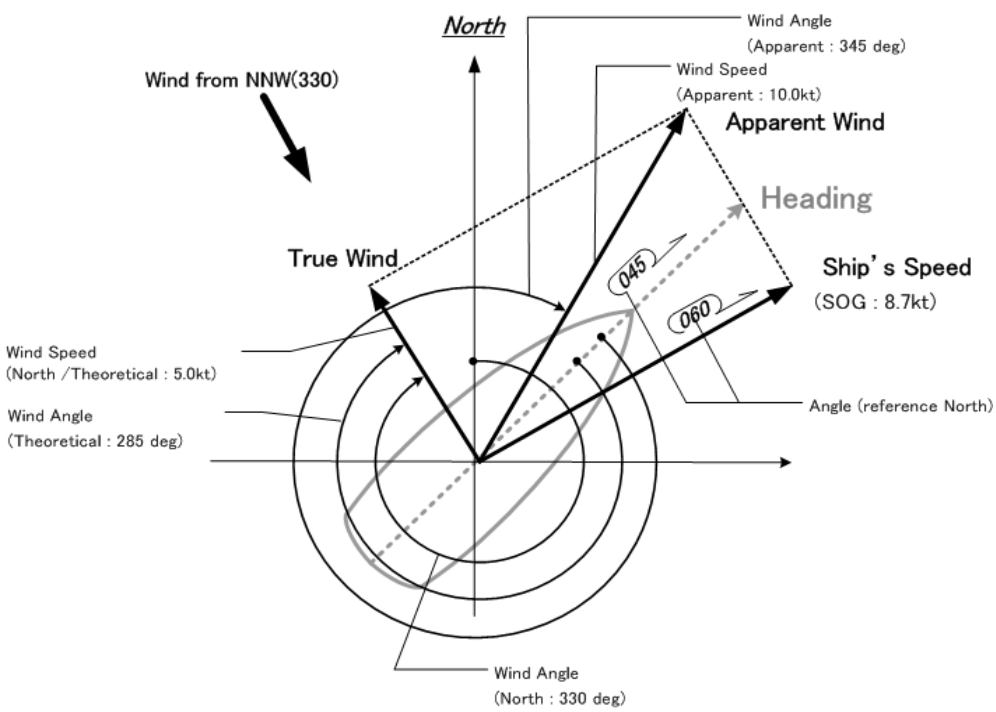
CH. 25: EMBEDDED TIDE, CURRENT & CLIMATE ALMANAC

The advent of ECDIS and other electronic charting systems provides the Mariner with a new navigation aid that is capable of displaying a wide variety of information. As an automated decision aid capable of continuously determining a vessel's position in relation to land, charted objects, aids-to-navigation, and unseen hazards, an electronic chart is an entirely new approach to maritime navigation. However, to fully realize its potential, ECDIS and other electronic charting systems should provide information beyond that which is contained on a paper nautical chart.

The provision of supplemental information that is in addition to that which is shown on a paper nautical chart is specifically mentioned in the IMO Performance Standards for ECDIS. In particular, the definition of an ENC states that it should contain '*all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart which may be considered necessary for safe navigation*'.

25.1: Force and Direction of the True Wind

ECDIS can display and output wind data in the following three formats:
Apparent: Wind meter-measured wind speed and direction.
Wind angle reference: Heading
North: True wind angle, true wind speed
Wind angle reference: True North
Theoretical: True wind angle, true wind speed
Wind angle reference: Heading
The illustration below shows wind speed and direction with given ship data.
The wind values are as shown below.
Ship information:
COG: 60 deg SOG: 8.7 kt
Heading: 45 deg
Wind angle Wind speed
Apparent: 345 deg 10 kt
North: 330 deg 5 kt
Theoretical: 285 deg 5kt



25.2: Current Flow

Similar to tidal/water level information, several electronic chart system manufacturers provide information on current flow as functional capability. Since most of the current flow that a maritime vessel encounters in coastal waters is caused by tidal changes, this information is often provided in similar format as tide tables (e.g., alphanumeric text). However, some electronic chart systems provide graphics or charts showing current flow vectors (icons) that indicate current flow velocity and direction within a selected geographical area. Similar to tidal heights, selected parameters include date, time, and number of days to be calculated. While this information can be helpful fro route/voyage planning, in many type-approved ECDIS equipment this information is displayed separate from the ENC or raster data. As such, it may have limited capability for route planning/monitoring since it is not integrated into ENC.

25.3: Tides/Water Levels

Several electronic chart system manufacturers provide tidal information as an additional functional capability. This information can be displayed as alphanumeric text (e.g., tide tables), or as graphs showing the height of tide for a selected geographical area. Some of the selected parameters include date, time, and number of days to be calculated. While highly useful, this information is usually displayed separate from the ENC or raster data.

In 2001, *SevenCs* developed a tide-simulation model for a ‘tide-adjusted’ ENC. Prototype ENC data sets were produced for two ports: Singapore and Schelde/Vlissingen in the Netherlands. Further enhancements included the establishment of designated tidal zones within the overall area. When coupled with either forecast or real-time tidal information, the main benefit to the Mariner would be decision support for voyage planning. With a tide-adjusted ENC, two types of information are particularly useful:

1) time/duration for vessel transit (high vs. low tide);
2) amount of vessel draft (and/or underkeel clearance) that would occur.

While the benefits of this functional capability are clear to most Mariners – particularly those operating deep draft vessels - the operational implementation of this functional capability with ENCs and ECDIS has yet to occur. This is due in part to the fact that the current IHO S-57 data standards do not allow for ENC depth information to be ‘adjusted’ based on tides or water levels. However, it is expected that future edition of IHO S-57 (Edition 4) will accommodate this functional capability. However, there is some concern about the accuracy of predicted or forecast tidal heights and the geographical area over which this would apply. Generalizing tidal information for predetermined tidal zones that are some distance from the tidal station can result in information that is not suitable for making precise decisions on actual depth or time of depth.

25.4: Weather/Oceanographic

Several electronic chart systems have a capability to receive and display a variety of weather and oceanographic-related information. Information parameters include:

- Temperature;
- Wind speed and direction;
- Height, direction and period of wind caused waves and/or swell;
- Atmospheric pressure;
- Type of precipitation (e.g., rain, snow);
- Likelihood of freezing spray.

Depending on the installed electronic chart system and shipboard communication systems, some users can subscribe to weather forecast information provided by the UK Meteorological Office or the National Ocean Service, NOAA (USA).

For type-approved ECDIS equipment, there are ongoing efforts by HGMIO to develop appropriate S-57 objects/attributes and S-52 colors and symbols for weather-related information. Liaison has also been established between IHO and the World Meteorological Organization (WMO) to develop future standards for data and display.

CH. 26: ROUTE SCHEDULE

The real-time graphical display of the ship's current position on an electronic chart system and the ship's course and speed as a vector is of such a high informational value. Nevertheless, additional alpha-numeric data are also provided for the most important navigational information.
For example:

- Latitude and longitude of own ship's position;
- Gyro course and log speed; course and speed over ground;
- Distance and bearing of the cursor;
- Cross track distance;
- Chart datum in use;
- Current position fixing system (and its performance).

Other values shown may include the under keel clearance, rate of turn, quality criteria of the position fixing system, udder angle, setting of the engine room telegraph, waypoint related data, cross-track distance as well as environmental data like tidal levels, speed and direction of currents and wind, etc.. In narrow fairways or in ports, these values must be very precise. The mode of presentation varies from system to system: information bars, background pages, window display. Several systems let the Watch Officer configure the presentation of this information.

26.1: Information in Route Sidebar (Example only)

The following information is shown in the route sidebar:
Information from route monitoring:

i. **Route:** Name of monitored route
ii. **Plan Speed:** Planned speed to approach "To WPT".
iii. **Plan:** Planned course between previous WPT and "To WPT".
iv. **Route:** Calculated set course to follow the monitored route, including off track, drift and gyro error compensation.
v. **Ch LIM:** Planned width of channel to approach "To WPT".
vi. **Off track:** Perpendicular distance the ship is from the intended track.
vii. **To WPT:** The waypoint which the ship is approaching.
viii. **Dist WOP (Wheel Over Point):** Distance to the point where rudder order for course change at "To WPT" will be given.
ix. **Time:** Time to go to WOP (dd:hh:mm:ss).
x. **Turn RAD:** Planned turning radius at "To WPT".
xi. **Turn rate:** Calculated rate of turn which is based on current speed and planned turning radius.
xii. **Next WPT:** The WPT following the "To WPT".
xiii. **Next:** Planned course between "To WPT" and "Next WPT".

Route: HELSINKI	
Plan Speed	30.0 kn
Plan	202.9 °
Route	202.9 °
Ch LIM	185 m
Off track	< 2 m
To WPT	6
Dist WOP	4.67 NM
Time	15:07
Turn RAD	1.0 NM
Turn rate	17.7 °/min
Next WPT	7
Next	250.1 °

The following information is calculated from data of positioning sensors and from route monitoring data:
i. **Route**
ii. **Off track**
iii. **Dist WOP**
iv. **Time**
v. **Next**

26.2: Using the ETA Application in ECDIS

Estimated time of arrival to a waypoint is calculated by the ECDIS. The operator can select waypoint number and speed profile for calculation in the Monitoring page of the Monitor Route dialog box.

SPD profile:
There are three calculation strategies:
- **Plan:** The system calculates with optimization made in route planning.
- **Trial:** You can enter speed to test ETAs with different speeds.
- **Current:** The system calculates ETAs using average speed of last five minutes. Note that if Speed profile is selected as Current, own ship average speed (i.e., speed for calculation) the Trial speed box replaces the Average Speed box and trial speed is shown in that box.

Average:
Select Average from the Speed profile box to enter desired speed for calculation of ETA to waypoint.
Speed profile is changed to Average speed. You can enter Average speed and system will calculate ETAs.

Plan: This displays ETA at final WPT. Value also appears in the Parameters page of the Plan Route dialog box.

Off Plan: Indicates time difference between planned ETA and calculated ETA to final WPT.

Suggested SPD: The system calculates the suggested speed so that ETA to the final waypoint is the same as the planned ETA, if the type of optimization is "Time table".

CH. 27: USER CHARTS IN ROUTE PLANNING

User charts are simple overlay charts that the operator makes for his own purposes. They can be displayed on both the radar display and the electronic chart. These charts are intended for highlighting safety-related items like position of important navigation marks, safe area for the ship, etc. User charts areas can be used to activate alerts and indications based on operator-defined danger symbols, lines and areas. When route or your ship estimated position is going to cross a user chart symbol, line or area that is defined as a dangerous one, an alert or indication is generated by the system.

A user chart consists of points, lines and letter/number, symbols, etc. Size of user chart is limited to have the max. number of items below:
• 200 Points
• 2000 Lines
• 1000 Symbols (alphanumerics)
• 50 Areas; an area can have 20 corner points.

The user chart is displayed on the radar display and its position and shape is based on the ship's actual position. When your ship is moving in the area covered by the user chart, the elements of the user chart are superimposed on the radar overlay, with max. 80 nearest elements of drawing point displayed. The user charts can also be shown on the ECDIS display. In this way the radar display can be kept as "clean" as possible for radar target detection.

27.1: Objects of User Charts

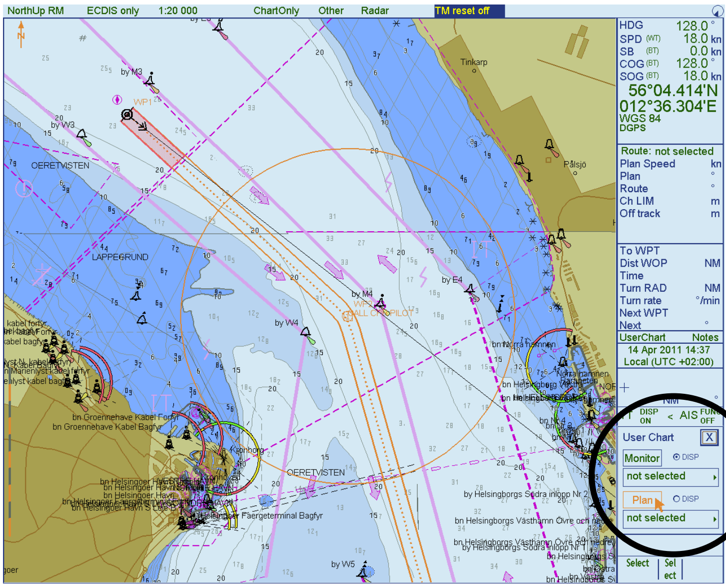
Below is a description of the objects used in a user chart.
- ***Line:*** You can define six different types of lines. Lines can be used in chart alert calculation and/or display on the radar:

- Navigation lines: Displayed on both radar overlay and ECDIS. Navigation lines are reference lines for coastline.
- Coastline: Displayed on the ECDIS display only. Coastal line is usually a well-defined (by chart digitizer) multi-segment line showing the coastline. The operator is able to create this type of line in case there is no suitable chart available over desired area in ARCS or S57 format.
- Depth contour: Displayed on the ECDIS display only. Depth line shows the selected depth levels. The operator is able to create this type of line in case there is no suitable chart available over desired area in ARCS or S57 format.
- Route line: Displayed on both radar overlay and ECDIS. Route lines are zones for anchoring, traffic separation lines, etc.
- NMT (Not More Than) line, NLT (Not Less Than) line: A danger bearing or clearing line. Single line with an arrowhead directed at the base of a charted object. Displayed on ECDIS only.

- ***Area:*** User can define closed areas that the system can use to detect safe water areas. If route or estimated ship position is going to cross the area, the system generates a warning to the operator. These areas can be used to specify safe areas as defined by the master or by the policy of the ship's owner. They are always available regardless of the type of chart material used.
- ***Symbols:*** User selectable symbols can be displayed on both displays or on the ECDIS display only. Symbols are used to indicate buoys, lighthouses, fixed targets, wrecks, etc. Symbols can be used in chart alert calculation.
- ***Tidals:*** Displayed on the ECDIS display only. Tidals can be used to make own notes about tides at operator defined points.
- ***Points:*** It doesn't itself have any symbol on the radar screen, but it is a very important element of a user chart.

27.2: Modes of User Charts

A user chart can be chosen for the monitoring mode, which means that it is displayed on connected ARPA radar display and it can be used in chart alarm calculation.
Another user chart mode modifies the user chart planning mode. In the planning mode, a user char is only displayed on the char radar display; it is not displayed on the connected ARPA radar nor is it used in chart alarm calculation. It is possible to have both the monitored and planned user chart at the same time if separate plan and monitor units are used. Eventually the monitored and planned user charts copy the operation of monitored and planned routes. Below is an example how to know which user chart is used for monitoring mode and which one is used in planning mode.



The User Chart field in the information area where it can be selected for the monitoring or planning mode

Create: User can create a new user chart.
Backup and Restore: User can make backup copy of user chart or restore user chart from backup device.
Combine: User can combine two or more user charts together.
Point report: Generates report about points in a user chart.
Line report: Generates report about lines in a user chart.
Area report: Generates report about area objects in a user chart.
Symbols report: Generates report about symbols in a user chart.
Tidal report: Generates report about tides in a user chart.
Full report: Generates report about all the objects in a user chart.
Report for radar: Generates report about all the objects in a user chart that are displayed on the radar screen.

27.3: Creating a User Chart

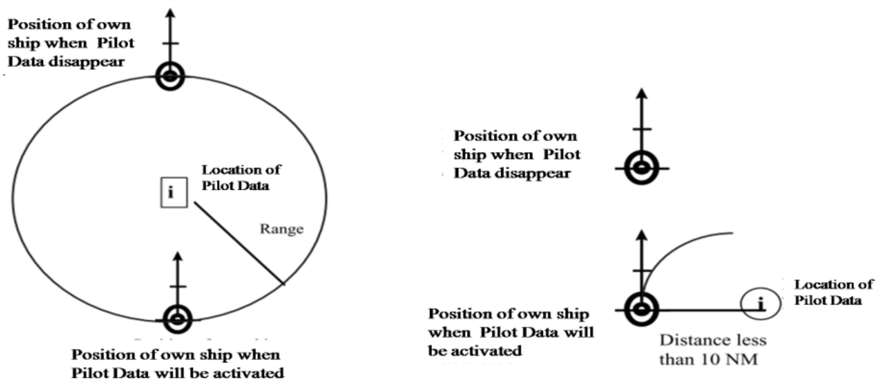
You can create and modify a user chart when you have chosen the planning mode of user chart.

27.4: Pilot Data

A navigation-related notebook is called "Pilot Data". Pilot Data is a "notebook data" file that provides messages for the operator relative to a specific ship position in the monitoring mode. The operator specifies range for each Notes record. The ECDIS compares Notes range and your ship's position and displays Notes when your ship goes within the range set for the Notes. (See figure below.)

The operator may assign a brief message that will appear on the radar display together with the notice of the proximity of the relevant point.

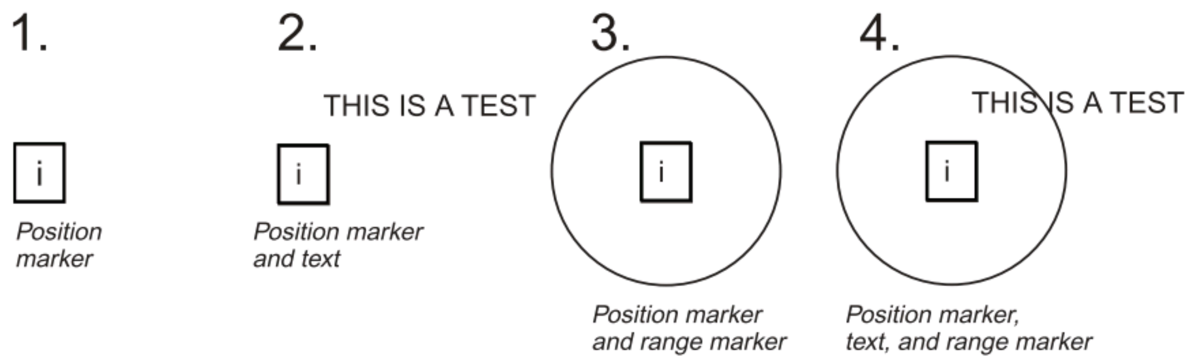
While the ship sails, notebook pages (= records) in the selected Notes file are compared with your ship's position once per minute to select Notes. Further, when the ship has passed a waypoint, the system will make a comparison against your ship's position. If the system finds that you have arrived within a new Notes notebook page, it generates the alert "5001 Pilot Data: New Record".



Alert mode "when entering range" selected

Alert mode "when passing" selected (range automatically selected to 10 NM)

27.5: Using Pilot Data



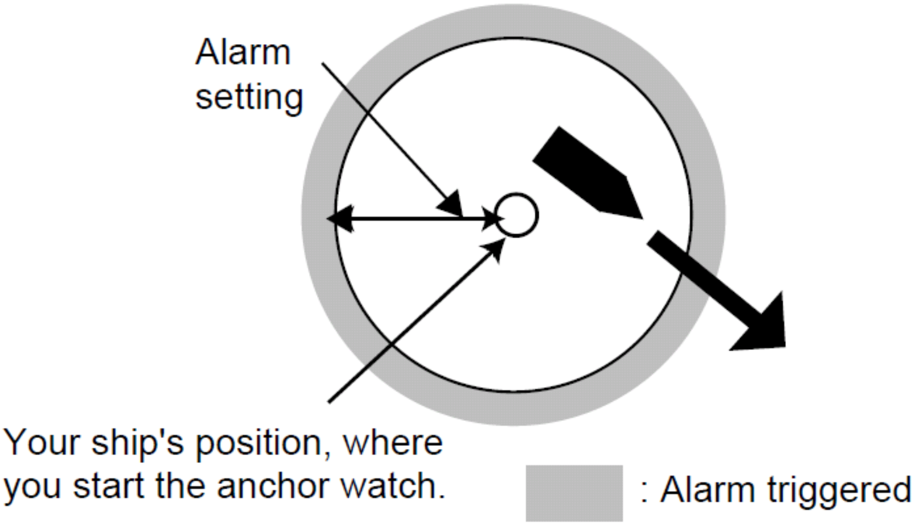
Four different variations as examples of how Pilot Data is presented on the chart area:
1. Position marker
2. Position marker and text
3. Position marker and range marker
4. Position marker, text and range marker

27.6: Creating New Pilot Data

You can create and modify Pilot Data, and this can be done in planning mode. It is recommended to use the true motion display mode while editing.

27.7: Anchor Watch

Anchor watch checks to see if your ship is drifting when it should be at rest.



LESSON 4: ECDIS TARGETS, CHARTS, AND SYSTEM

CH. 28: ARPA TRACKED TARGET OVERLAY

Most installations will allow radar tracked targets to be displayed on ECDIS. The target identification name or numeric identifier should automatically match that shown on the radar. In principle, there could be different restrictions on the maximum number of targets displayable on the radar and the ECDIS but this is unlikely to be a real issue. In practice, it is unlikely that the ECDIS will not be able at least to match that of the radar. An alert will be given if this limit is exceeded because targets significant to navigation could be dropped.

On some configurations the target vector type (for example true or relative, ground- or water-referenced) will always match that selected on the radar. On other configurations, different vector types can be displayed on the radar and ECDIS. Although this may be useful in some situations it could also be the cause of confusion, and so should only be used with due caution. When target vector information is being displayed on ECDIS, there will always be an indication of whether the vectors are relative or true, and if true, whether they are sea- or ground-stabilized.

It is only necessary to overlay tracked radar targets on to ECDIS when there is a need to understand their relationship with charted features or to act as a check on navigational integrity. The overlay is particularly useful when using radar with no chart overlay facilities. It is often useful to be able to see the immediate geographical area that specific targets are within, in order to increase situational awareness. This can help to make decisions on the probable intentions of a target. Decisions on collision avoidance must not be taken from information appearing on ECDIS alone as it is not designed to be the prime collision avoidance display. It is essential, not least to comply with the Collision Regulations, that such decisions are based on visual and direct radar display observation with the additional information from ECDIS being made to support the decisions.

Concerning ARPA target overlay, there is one serious risk: If only the ARPA data, not the whole radar video, are integrated into the electronic chart, only part of the ship traffic is displayed because targets not acquired on the radar screen are not displayed in the electronic chart. This is extremely dangerous. The Watch Officer must be extremely vigilant using this type of overlay and, in addition to the ECDIS-ARPA display, observe the original radar video on a second screen as well.

28.1: Requirements, Problems and Reservations

Several requirements must be fulfilled to achieve the full benefit of integrating ECDIS and radar.

➢ **Requirements from IMO Performance Standards**

According to the IMO Performance Standards for ECDIS, the radar information may be included in ECDIS as long as

- the ECDIS display is not impaired;
- ECDIS and radar information are clearly differentiated;
- Radar information can be removed from ECDIS by a single operator action.

Likewise, the IMO Performance Standards for Radar [IMO Radar] allow inclusion of selected layers of ENC information on the radar display. The overall intent is that the ECDIS display will not become illegible because of radar information obscuring the chart information and vice versa.

➢ **The Clutter Problem**

Clutter by sea, rain and other unwanted echoes in the ECDIS radar overlay is a serious problem. It is possible to have a radar ‘underlay’ instead of an ‘overlay’. The radar information has been reduced to only those radar echoes which have no corresponding objects stored in the digital chart database. The radar underlay greatly contributes to reducing radar image clutter. However, this procedure is effective for unwanted land echoes, but not for sea and rain clutter.

- High accuracy and resolution of ECDIS and radar;
- High accuracy of position (e.g. DGPS), speed and course sensors;
- Monitoring and status indication of all sensors;
- Reference management of sensor data (adjustment of the positions of radar antenna, GPS antenna, turn center of the ship);

• Adjustment of projection and horizontal reference system - Radar (azimuthal equidistant projection) - ECDIS (Mercator projection or chart horizontal datum) - GPS (WGS-84); • Common north orientation of ECDIS and radar; • Common repeat rate of ECDIS and radar information; • Adjustment of radar range (nm) and chart scale (1:n); • Recognizability of radar image and ECDIS information as such; • Adjustment of display method (true or relative motion display); • Appropriate referencing of the radar image and ARPA vectors (over the ground); • Manual adjustment of own ship's position until both images are matching (questionable); • Operational independence of ECDIS and radar/ARPA.

Table 28.1: Functional and technical requirements for overlaying ECDIS and radar displays.

➢ Functional and Technical Requirements

A precise ship position (accuracy of a few meters) is an essential element to achieve accurate matching of images in situations like entering the harbor with chart and radar. At present, only the locally or regionally available DGPS is appropriate. In addition, scales, horizontal reference systems, projections, orientations, etc. must match or be adjusted to match. The essential requirements for the high-quality ECDIS radar overlay are set out in Table 28.1 (above). The Watch Officer must know, and take into considerations, the capabilities and limitations of the features of such integrated systems, including the error effects.

➢ Potential Problems and Reservations

Although the overlay of radar and ECDIS is now recognized as contributing to overall navigational safety and required by users, the development was hesitant at the beginning for various reasons. In the meantime, some well-known counter-arguments have weakened, have been resolved (Table 28.2 [below]) or have even changed to the opposite. Essentially, the remaining problems (e.g. clutter) and reservations (e.g. information overflow) are outlined in Table 28.3 (below). A perfect match may, however, not always be possible because of e.g. tide-variable coastlines, compass errors, etc..

• Navigation and Collision Avoidance The conventional separation of navigation and collision avaoidance is not any more adhered to so strongly, their integration is now increasingly welcome. • Ground-stabilization vs. Sea-stabilization The controversial view that ECDIS requires ground-stabilized motion display and radar requires water-stabilized motion display is resolved because it is increasingly accepted that ground-stabilization in many cases is also superior in radar use.

• Discrepancies Slight discrepancies between ECDIS and radar images which may appear on the integrated display (e.g. position shifts, differences in north orientation, various reference systems, etc.) were earlier considered as obstacles to overlaying ECDIS and radar images. Today, they are valued as aid to system control. Needless to say, that these differences exist also in the separated displays, but ate not so easy to notice.

Table 28.2: Resolved counter-arguments for the integration on ECDIS and radar.

• The clutter by radar sea-state echoes cannot be completely removed; • Information overflow may occur and must be avoided; • ECDIS and radar information must not obscure each other; • Because the radar image shows the front edges of the target more accurately than its center and rear part, a slight shift of the radar target may appear; • In case of the failure of the entire system, the Watch Officer loses two navigation systems. Suitable redundancy must be provided; • The integration of ARPA targets only, instead of the whole radar image, results in the display of only those targets in ECDIS which have been acquired by the Watch Officer on the radar, but not all (!) targets; • Should the priority of ECDIS and/or radar (overlay, underlay, transparency) be changed by the watch officer?

Table 28.3: Problems and reservations still related to ECDIS radar overlay.

➢ Summary

A system integrating electronic chart and radar information provides important safety-related advantages. In normal cases, it can be used as the primary system for both navigation and collision avoidance. Even if the Watch Officer does not want to use the ECDIS radar overlay continuously, he may use it on demand for double-checking own ship's position.

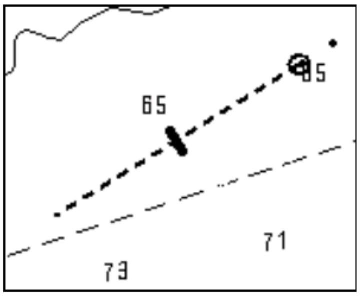
Concerning the bridge configuration, it is expected that, at the ship control station, there are two multi-functional workstations which can be used for safely navigating the vessel, i.e. for both grounding and collision avoidance. Depending on the situation or task at hand, the ideal situation would be that either display can be used as:

- An electronic chart for route monitoring (displaying own ship's sea area), or
- A radar video display only, or
- An electronic chart with radar video overlay, or
- A radar display containing selected layers of chart information, or
- A second electronic chart for route planning (displaying remote sea areas).

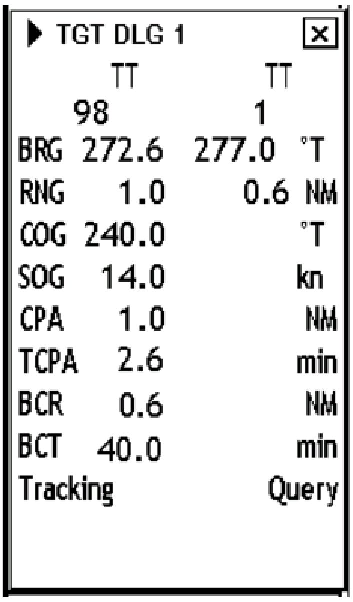
Moreover, it may be useful to have another station located at the back of the bridge for route monitoring purposes.

28.2: Displaying Radar/ARPA Target Data

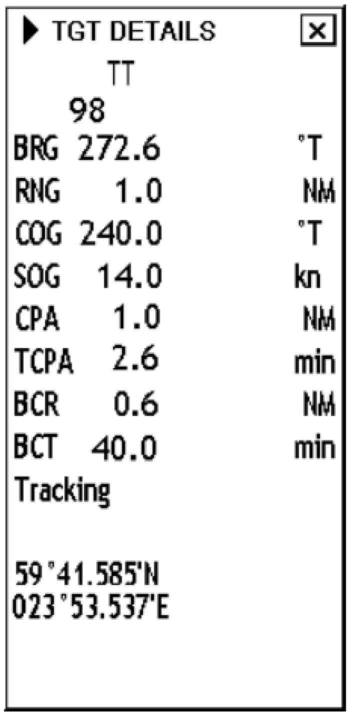
On the ECDIS display, a desired tracked target can be monitored.



ARPA Radar Target on ECDIS Display



ARPA Target Display Window



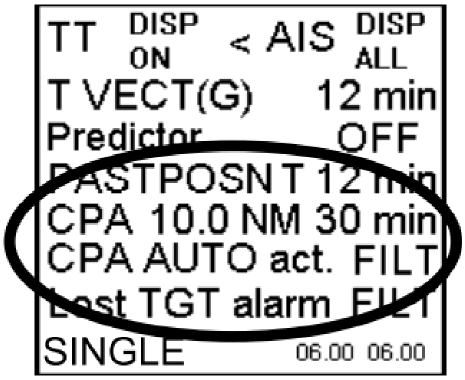
ARPA Target Display with details

The basic target display dialog for a tracked target consists of the following information:

- Target's number
- Bearing (BRG) and distance (RNG) of the target from own ship
- Speed Through Water (STW) and true course (CRS) of the target, when using True Vectors (S) or COG and SOG when using other speed vector modes.
- CPA and TCPA. Note that if TCPA has a negative value, this means that you have already passed the closest point and the tracked target is going away from own ship.
- Bow Crossing Range (BCR) and Bow Crossing Time (BCT)

The detailed target display dialog for a TT displays the contents of the basic TT display plus the following information. To display detailed information, push the left mouse button.

- Status of target. Status can be Query, Tracking or Lost. "Query" indicates a new target for which there is not yet enough tracking history to have target speed, course, CPA and TCPA available.
- Position of target (Lat, Lon)



User can set Closest Point of Approach (CPA), and Time for CPA (TCPA) to define dangerous ARPA Targets. CPA and TCPA limits are common for ECDIS display and danger target log function of ARPA and AIS targets. On the ECDIS display, a dangerous ARPA target blinks in red color.

Note that the CPA and TCPA limits are only for ECDIS. ARPA radar has its own setting for dangerous targets and thus a target which is dangerous on the ARPA display can be safe on ECDIS and vice versa. If an ARPA target is within the CPA and TCPA settings, it is shown as a dangerous ARPA target on the ECDIS display.

28.3: Setting CPA and TCPA limits

You can set the CPA and TCPA limits used by the ECDIS.

28.4: Source of ARPA Radar Targets

This can be done by checking the source.

28.5: ARPA-Related Alarms

The alarm **"ARPA Radar comm error"** indicates failure to receive data from connected ARPA radars. The alarm **"Source ARPA Radar changed"** informs that the system has automatically changed the source of ARPA radar targets from current source to a new source. The reason for automatic change is that the communication with current source is in failure.

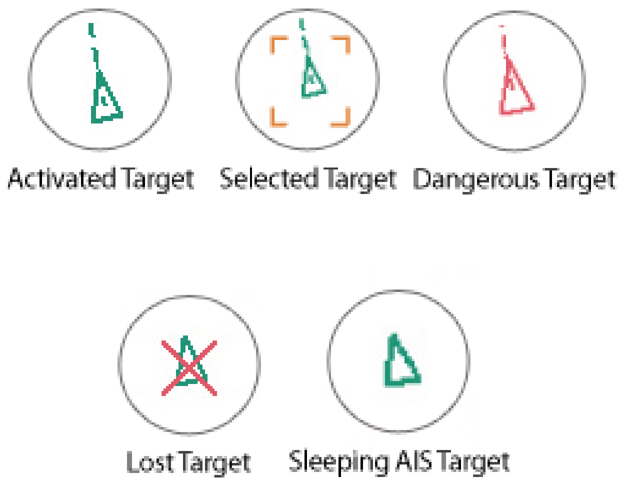
CH. 29: AIS FUNCTIONS

The **Automatic Identification System** (**AIS**) is an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships and AIS Base stations. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.

Information provided by AIS equipment, such as unique identification, position, course, and speed, can be displayed on a screen or an ECDIS. AIS is intended to assist a vessel's watchstanding officers and allow maritime authorities to track and monitor vessel movements. AIS integrates a standardized VHF transceiver with a positioning system such as a LORAN-C or GPS receiver, with other electronic navigation sensors, such as a gyrocompass or rate of turn indicator. Vessels fitted with AIS transceivers and transponders can be tracked by AIS base stations located along coast lines or, when out of range of terrestrial networks, through a growing number of satellites fitted with special AIS receivers.

Integration of the ECDIS and AIS can have the following benefit: “It may be possible to detect, monitor and manage the movement of vessels without having them in visual sight or on radar. As a result, decisions on collision avoidance measures could be made from a remote location.”

When connected to AIS, ECDIS (the FEA-2107/2807 as sample only) can store the information about up to 1,000 AIS targets in its storage buffer and displays up to 200 AIS targets within the operator-set range on a display. This helps operators enhance their situational awareness around own ship.



The frequency for update of AIS transponder-sent data depends on speed and course of tracked AIS target. The table below shows the IMO standardized reporting rates for the AIS transponder. Based on the table below, the ECDIS defines which AIS targets are in tracking or lost. When you acknowledged of lost target alert, AIS symbol will be removed on ECDIS display. If lost target is not acknowledged, automatic removal of AIS symbol is done as shown table below.

Type of Ship	IMO nominal reporting interval	Lost target indication (reporting interval >)	Pre-set rate for automatic removal of lost target
Class A: speed between 0-14 kn	10 s	50 s	430 s
Class A: speed between 14 - 23 kn	6 s	30 s	430 s
Class A: speed greater than 23 kn	2 s	10 s	430 s
Class A: anchored, moored, not under control or grounded, speed between 0-3 kn	3 min	10 min	36 min
Class A: anchored, moored, not under control or grounded, speed greater than 3 kn	10 s	50 s	36 min
Class B: CS speed between 0 – 2 kn	3 min	10 min	36 min
Class B: CS speed greater than 2 kn	30 s	150 s	430 s
Class B: SOTDMA speed between 0 – 2 kn	3 min	10 min	36 min
Class B: SOTDMA speed between 2 - 14 kn	30 s	150 s	430 s
Class B: SOTDMA speed between 14 - 23 kn	15 s	75 s	430 s
Class B: SOTDMA speed greater than 23 kn	5 s	25 s	430 s
Class A and Class B: no speed available	N/A	10 min	36 min
ATON	3 min	10 min	30 min
SAR	10 s	50 s	430 s
Base station	10 s	50 s	430 s
SART	N/A	18 min	30 min

An AIS transponder “sees” all ships fitted with an AIS transponder belonging either
• Class A AIS
• Class B AIS
Additionally the AIS transponder receives messages other than ships:
• AIS Base station
• AIS on airborne SAR craft
• AIS on ATON (AIS aid to navigation)

There can be several hundreds or several thousands of AIS targets, and of those only a few will be significant for your ship. To remove unnecessary AIS targets from the ECDIS display, the feature "active and sleeping AIS targets" is available. Initially any new AIS target received by an AIS transponder is not-active (="sleeping"). Such non-active targets are shown with a small triangle. User can pick any AIS target and change it from non-active to active. Active AIS targets are shown with a large triangle with speed vector, headline, rot indicator, etc. Further, the operator can pick active AIS targets and change their status to non-active.

29.1: The Automatic Identification System

The Ship-borne Automatic Identification System (AIS) as specified by IMO is a ship and shore based broadcast system operating in the VHF maritime band.

It is capable of sending and receiving ship information such as identity, position, course, speed, ship particulars and cargo information to and from other ships, suitably equipped aircraft and can handle over 2000 reports per minute and updates information as often as every two seconds. It uses Self-Organizing Time Division Multiple Access (SOTDMA) technology to meet this broadcast rate and ensure stable and reliable ship-to-ship and ship-to-shore operation.

When used with an appropriate graphical display, shipboard AIS enables the provisions of fast automatic and accurate information regarding risk of collision by calculating the Closest Point Approach (CPA) and Time to Closest Point Approach (TCPA) from the positional information transmitted by target vessels.

29.2: AIS Data in the Electronic Chart

The introduction of such an identification system broadens the area of usage of the electronic chart, because through conveying of the actual navigational data of the vessels in the surrounding sea area can these vessels not only be shown and the numerical values of their movement parameters displayed on demand; in addition can the correlation with the radar observations be shown and the echoes from vessels securely as such be identified and allocated. Typical delays in ARPA evaluation of the radar echoes data during the maneuvers of the observed ship (change of course or speed) can be almost completely compensated through this technology. AIS technology therefore supplements effectively Radar/ARPA for collision avoidance done at the electronic chart. These advantages however, can give their full value only when the mechanism for displaying and evaluation of the AIS information is successful harmonized with both other systems delivering local information – radar/ARPA and VTS.

29.3: AIS Symbology

The accelerated introduction of the AIS carriage requirement was not accompanied by the firmly agreed requirements for the display and integration of the navigational information provided by the AIS together with other information of the same type already available on board. Practical experiences gained with AIS operation in the meantime have evidently shown the inevitable need for a harmonized presentation of all navigation related information provided from various sources like Radar, ARPA, ECDIS and AIS, and processed together on the various navigational displays on the ships bridge. On behalf of IMO, requirements for harmonized presentation have been developed in 2004, which consists of two major parts:

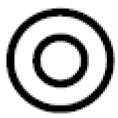
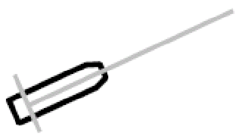
- Performance Standards for the Presentation of Navigation-related information on Shipborne Navigational Displays [IMO PS NavDisplays];
- SN circular on Guidelines for the Presentation of Navigation-related Symbols, Terms and Abbreviations [IMO Circular NavSymbols].

These requirements for harmonized presentation, adopted by IMO MSC79 in November 2004, will become mandatory from July 2008 and will take precedence over existing equipment performance standards when conflicts regarding presentation issues occur. However, Navigation equipment producing industry has started their implementation right already and the harmonized presentation on navigational displays will appear on new buildings, retrofits and updated equipment from mid of 2005.

The requirements are based on eight basic premises:

1. Symbols are based on symbology currently in use;
2. Only minimum changes to existing symbols have been applied;
3. New or modified symbols have been introduced only when needed;
4. Symbols are arranged into logical functional groups with a common base symbol;
5. Symbol are consistent between logical functional groups;
6. The total number of symbols should is kept to a minimum;
7. Symbols are distinguishable by shape or outline rather than colour alone; and
8. Symbols are designed using a s few colours as possible.

As a result, a consistent solution was determined for the presentation of the own ship symbol, radar symbols and AIS symbols. These three classes of symbols are discriminated by shape, e.g., radar symbols based on a circle, and AIS symbols based on an oriented triangle. For radar and AIS targets the functional state, e.g., danger state, is coded consistently by applying additional attributes to the base symbol. The resulting definition of harmonized symbols for navigation-related information adopted by IMO (IMO Circular NavSymbols) and the operational conditions connected which are shown in Tables 29.1, 29.2 and 29.3 (below).

Topic	Symbol	Description
Own ship Symbol		Double circle, located at own ship's reference position. Use of this symbol is optional, if own ship position is shown by the combination of Heading Line and Beam Line.
Own Ship True scale outline		True scale outline located relative to own ship's reference position, oriented along own ship's heading. Used on small ranges/large scales.

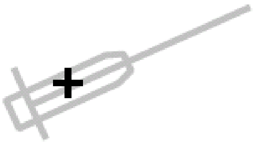
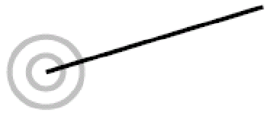
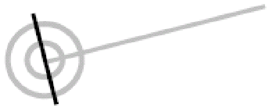
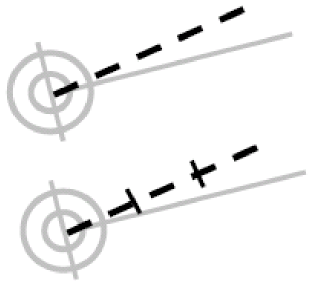
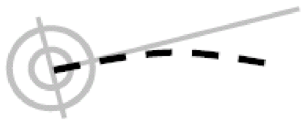
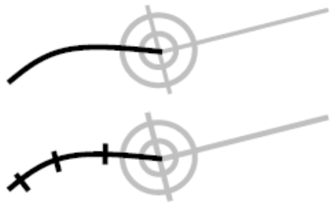
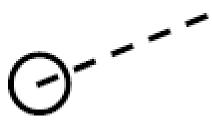
Own Ship Radar Antenna Position		Cross, located on a true scale outline of the ship at the physical location of the radar antenna that is the current source of displayed radar video.
Own Ship Heading line		Solid line thinner than the speed vector line style, drawn to the bearing ring or of fixed length, if the bearing ring is not displayed. Origin is at own ship's reference point.
Own Ship Beam line		Solid line of fixed length; optionally length variable by operator. Midpoint at own ship's reference point.
Own Ship Speed Vector		Dashed line - short dashes with spaces approximately twice the line width of heading line. Time increments between the origin and endpoint may optionally be marked along the vector using short intersecting lines. To indicate Water/Ground stabilization optionally one arrowhead for water stabilization and two arrowheads for ground stabilization may be added.
Own Ship Path prediction		A curved vector may be provided as a path predictor.
Own Ship Past track		Thick line for primary source. Thin line for secondary source. Optional time marks are allowed.

Table 29.1: Own ship symbology according to IMO SN 243 [IMO Circular NavSymbols].

Topic	Symbol	Description
Tracked Target including Dangerous Target		Solid filled or unfilled circle located at target position. The course and speed vector should be displayed as dashed line, with short dashes with spaces approximately twice the line width. Optionally, time increments, may be marked along the vector.

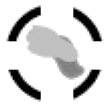
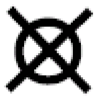
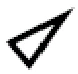
		For a **.Dangerous Target.**, bold, red (on colour display) solid circle with course and speed vector, flashing until acknowledged.
Target in Acquisition State		Circle segments in the acquired target state. For automatic acquisition, bold circle segments, flashing and red (on colour display) until acknowledged.
Lost Target		Bold lines across the circle, flashing until acknowledged.
Selected Target		A square indicated by its corners centred around the target symbol.
Target Past Positions		Dots, equally spaced by time.

Table 29.2: Tracked Radar target symbolization according to IMO SN 243 [IMO Circular NavSymbols].

Topic	**Symbol**	**Description**
AIS Target (sleeping)		- Isosceles, acute-angled triangle. - Triangle oriented by heading, or COG if heading missing. - Reported position should be located at centre and half the height of the triangle. - Symbol of the sleeping target should be smaller than that of the activated target.

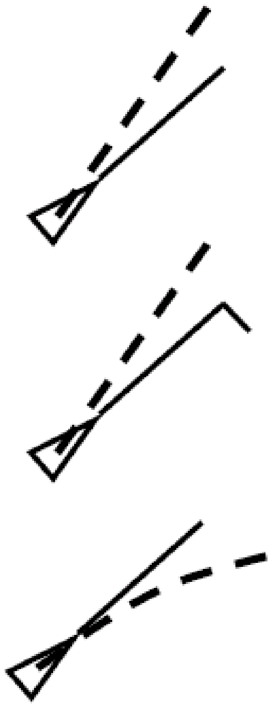
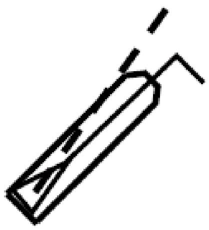
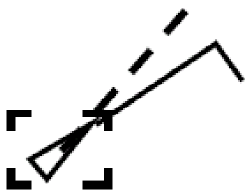
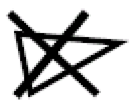
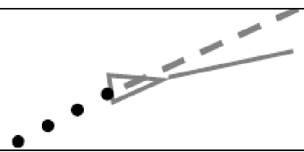
Activated AIS Target including Dangerous Target		- Isosceles, acute-angled triangle. - Triangle should be oriented by heading, or COG if heading missing. - Reported position should be located at centre and half the height of the triangle. - COG/SOG vector to be displayed as a dashed line with short dashes with spaces approximately twice the line width. Optionally, time increments may be marked along the vector. - Heading to be displayed as a solid line thinner than speed vector line style, length twice of the length of the triangle symbol. Origin of the heading line is the apex of the triangle. - Turn to be indicated by a flag of fixed length added to the heading line. - A path predictor may be provided as curved vector. - For a **'Dangerous AIS Target',** bold, red (on colour display) solid triangle with course and speed vector, flashing until acknowledged.
AIS Target – True Scale Outline		- A true scale outline may be added to the triangle symbol. - Located relative to reported position and according to reported position offsets, beam and length. Oriented along target's heading. - Used on low ranges/large scales.
Selected target		- A square indicated by its corners to be drawn around the activated target symbol.
Lost target		- Triangle with bold solid cross. - Triangle to be oriented per last known value. - Cross has fixed orientation. - Symbol flashes until acknowledged. - Target to be displayed without vector, heading and rate of turn indication.
Target Past Position		- Dots, equally spaced by time.

Table 29.3: AIS target symbolization according to IMO SN 243 [IMO Circular NavSymbols].

29.4: AIS Information Available

If a user realizes that an observed target warrants special attention or is dangerous, a function displays all available information in an alpha-numeric format. The important data for collision avoidance, such as times and distances of the imminent approach, are supplemented by the typical ship data and the actual movement parameters of the target ship. The received AIS information can also contain particulars on the actual position of the vessel with regard to the collision avoidance rules (e.g. 'draught hampered vessel'). Appropriate alarms can be also coupled with AIS targets. With AIS, the Mariner is no longer primarily dependent on visual identification in terms of running lights at night, or target bearing during the day. Table 29.4 (below) lists the various types of information distributed by each AIS radio transponder whereas Table 29.5 (below) contains the related update rates.

Static	Dynamic	Voyage Related
- MMSI – Maritime Mobile Service Identity - Call sign and Name - IMO number - Length and beam - Type of Ship - Location of position-fixing antenna on the ship and ships dimension	- Ship's position with accuracy indication and integrity status - Time in UTC - Course over ground - Speed over ground - Heading - Navigational Status - Rate of Turn	- Ship's draught - Hazardous cargo - Destination and ETA - Route plan

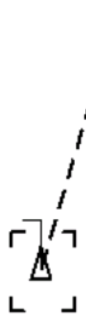
Table 29.4: Various types of information transmitted by each shipborne AIS radio transponder.

Update Rates of AIS	
Static information:	Every 6 min. and on request
Dynamic information:	Dependent on speed and course alteration
Voyage related information:	Every 6 min., when data has been amended, and on request
Safety-related message:	As required

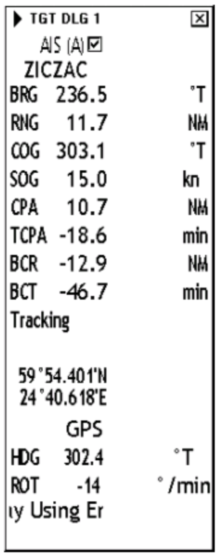
Table 29.5: Update rates of AIS dependent from the type of information transferred.

29.5: Displaying AIS Targets

Targets which are being tracked by an AIS transponder can also be displayed on the ECDIS display.



AIS target on ECDIS display



AIS target dialog window

Note: AIS and ARPA targets viewing limitations are as follows:

- AIS and tracked target are displayed on top of chart 1:1,000,001 for S57 charts.
- AIS and tracked target are displayed on top of chart 1:1,900,001 for ARCS charts. This allows display of AIS and tracked target on top of the largest scale ocean charts (original scale 1:3,500,000) when they are zoomed to "overscale".

29.6: Displaying AIS Target Data

Place the cursor on a desired AIS target and then push the scrollwheel. The AIS Target Dialog window appears, similar to the one shown below.

The Target Dialog window displays the following information for an AIS target:

- AIS Target **Name** or **Call Sign**
- **BRG:** True Bearing from own ship
- **RNG:** Distance from own ship
- **CSE:** True course of the target
- **SPD:** True speed of the target
- **CPA** and **TCPA**
- **BCR, BCT:** Bow Closest Range, Bow Closest Time

If more detailed information is needed, place the cursor in the Target Dialog Window and then push the left mouse button to get the Target Details window.

Note: Availability of data in the Target Details window is subject to the content the AIS transponder reports.

The operator can set Closest Point of Approach (CPA), and Time to CPA (TCPA) to define dangerous AIS targets. CPA and TCPA limits are common for ECDIS display and danger target log function of TT and AIS targets. The ECDIS display shows a dangerous AIS target with its symbol blinking, in red.

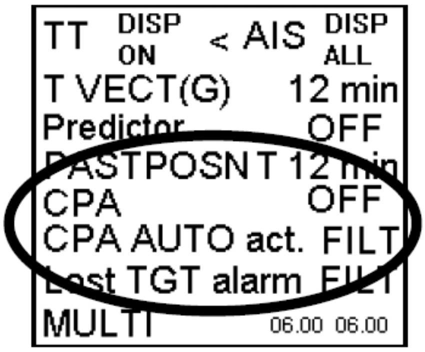
Note that the CPA limits are only for ECDIS. AIS has its own setting for dangerous targets and thus a target which is dangerous on the AIS display can be safe on ECDIS and vice versa. If an AIS target is within the CPA and TCPA settings, it is shown as a dangerous AIS target on the ECDIS display.

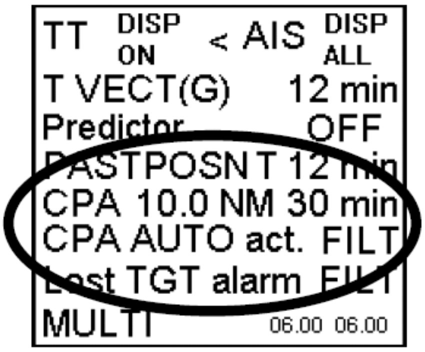
If an AIS target locates within the CPA and TCPA values, it is shown as a dangerous AIS target on the ECDIS display. Note that the same situation occurs with tracked target.

Note1: If your ship's position is based on Dead Reckoning, then CPA/TCPA and BCR/BCT values are not calculated and not displayed.
Note2: If TCPA has a negative value it means that you have already passed the closest point and the AIS target is going away from your ship.

29.7: Setting CPA and TCPA limits

You can set CPA and TCPA limits used by the ECDIS.





29.8: AIS Safety Message

You may send and receive messages via the VHF link, to a specified destination (MMSI) or all AIS-equipped ships in the area. Messages can be sent to warn of safety of navigation, for example, an iceberg sighted. Routine messages are also permitted. Short safety related messages are only an additional means to broadcast safety information. They do not remove the requirements of the GMDSS.

The Safety Message dialog box contains the following items:

Filter:	Select category of messages to show in the Safety Message menu.
Name:	Each message has an individual name based on time of creation or time of receiving of message.
Status:	Display status of selected safety message.
Send:	Display date and time when message is sent.

Org: Original message name is displayed here if selected safety message is reply for received message.
Vessel: AIS target related information is displayed in this field.
Address: Select how to send a safety message.
Msg Type: Select message format.
Channel: Specify channel for transmitting.

29.9: Source of AIS Target Related Alarms

The alarm "AIS Target Overflow" warns that the maximum number of AIS targets set to display on the ECDIS has exceeded the user-specified maximum range. It is possible that some of the AIS targets are not displayed on the ECDIS.

The alarm "AIS Target Storage Full" warns that the maximum number of AIS targets which can be stored for displaying on ECDIS has been exceeded.

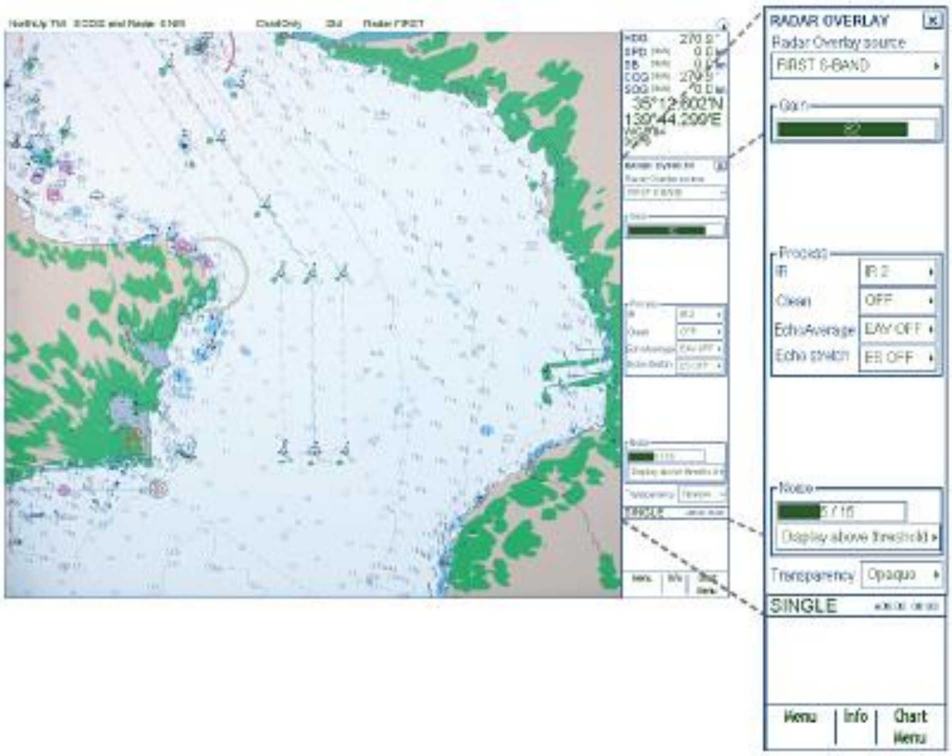
The alarm "AIS receive error" warns that data from an AIS transponder is not correctly received.

CH. 30: RADAR OVERLAY (RIB) FUNCTIONS

On some systems the radar image can be an overlay on the ECDIS. This puts a lot of data on the display and generally the image should not be retained for any length of time because it can be distracting for normal voyage monitoring. Its main use is to establish quickly whether ground-fixed targets, including ‘coastlines’, are appearing in their expected geographical position to aid the estimation of the integrity of the navigational situation. Note that the ‘coastline’ is the radar-apparent coastline, which is height related and except for special situations, such as when cliffs form the recognized coastline and could even be significantly different. The fact that it allows checks to be made on potentially numerous ground-fixed targets without any need to initiate tracks makes it an attractive option for integrity checking in many circumstances. It also eliminates any tracking errors that may be present in overlaid radar tracked target vectors.

A radar image can also be useful to identify which particular radar return is more likely to be that from a particular charted object. Before using it for such discriminatory work, ensure that good positional integrity has been recently verified.

The purpose of integrating an ECDIS with radar input is to improve the navigator’s situational oversight. The specific benefits of an ECDIS/radar overlay include collision avoidance, position monitoring, target identification, radar performance, shifted objects, false faraway detection, error detection, mutual check, reduced errors, reduced workload and system redundancy.



Radar overlay video can be received by two methods by ECDIS:
1. Through Radar overlay card fitted in the ECDIS
2. Through LAN from Radars, which are capable to send radar video to LAN

ECDIS has many features to support exact match in scale and orientation of the chart and radar echo image. Exact match of the radar echo image and chart is an essential security feature. If the radar echo image and the chart display match, then the mariner can rely on what he sees and the mariner also gets a very good confirmation that his navigation sensors (such as gyro and position receivers) operate properly and accurately. However, if the mariner is unable to achieve exact match, it is a very strong indication that something is wrong and he should not rely on what he sees.

Selected scale of displayed chart also defines scale of radar overlay. When you change the chart scale, the scale of the radar overlay is automatically changed. The maximum range of the radar overlay is 24 nautical miles.

The rule of thumb for range of displayed area:
• Chart scale 1:10,000 is almost equal to traditional radar range of 0.75 nm
• Chart scale 1:20,000 is almost equal to traditional radar range of 1.50 nm

30.1: The Radar Integrator Board (RIB)

The Radar Integrator board (RIB) is a hardware module installed in a system and designed for the reception of an analog video signal from the radar and its digital processing. The RIB enables the automatic detection, automatic acquisition and tracking of targets, computation and transmission of real-time information on the targets' coordinates and motion parameters to the system, as well as the formation of a radar picture to be displayed in combination with the electronic chart.

The combination of a chart, current coordinates and surface situation on a single display allows the sailing conditions to be assessed at a single glance with regard to the above-water dangers, as shown by the radar, and the submerged dangers, as specified by the chart.

The general-purpose channels for the synchronization and interfacing with the radar, as well as a programmable device for the communication with logs and gyros ensure the RIB interfacing with various types of navigation radars.

The capability of continuous recording of a radar picture and elements of the tracked targets motion with a subsequent playback on the electronic chart background enables reliable documenting of navigational conditions.

RIB Main Functions

➢ **Radar Signal Input**

- analog-digital conversion of radar signals;
- reception of information on the course and speed.

➢ **Radar Target Selection**

- suppression of sea clutter, interference from operating radars and other occasional clutter;
- detection of radar echoes with an adaptive threshold;
- selection of objects by size within a set range of values;
- determining the targets' gravity centres and measuring their;
- automatic acquisition and automatic tracking of targets.

  Note: The criterion for selecting targets for tracking is the availability, in several consecutive scans, of an echo with a higher intensity as compared to the background within a spatial locality fitting the set range in size and discrimination.
- automatic assigning of names to the new targets;
- determining the target's current courses and speeds;
- "lost target" moment fixing;
- computation, preparation and transmission to the NS of all the tracked targets" data cards including the following parameters:

  – number or name assigned to the target;
  – target status or type:
    "new target";
    "steadily tracked target";
    "target not observed";
    "target lost".
  – target's range (in nautical miles);
  – target's true bearing (in degrees);
  – target's relative course (in degrees);

– target's relative speed (in knots);
– target's true course (in degrees);
– target's true speed (in knots).

- **Formation of a Radar Image**
- formation of a digital radar image, enhancement of sea surface and coastline presentation (filtering and clutter suppression);
- conversion of the radar picture coordinates, orientation and scale;
- offsetting the effect of non-uniformity of antenna rotation on the formation of the radar picture;
- scan-to-scan accumulation for an improved quality of presentation;
- formation of surface radar images converted to suit the set parameters, for the display in the NS system.

30.2: Integration of Instruments and Data

The combined display of radar and electronic chart information is, in principle, rather easy to realize since ECDIS information as well as radar information (after the analogue-digital conversion) are presented in a digital format and their display media are comparable. The radar image usually has a range from 0.25 to 48 (or more) nm and is displayed on screens of e.g. 34 cm diameter with a typical resolution of e.g. 1280 x 1024 pixels.

Technically, the overlaying of ECDIS and radar data can be realized using the 'Multi-Layer Object Structure' which defines the priorities of chart data, radar video and ARPA targets (Fig. 30.1 (below)). Fig. 30.1 (below) shows the two components (electronic chart, radar image) and the result of the overlaying on the screen.
It is specified (IMO PS, IHO S-52) that

- radar video (opaque or transparent green) and ARPA data (blue green) are displayed in their own color;
- when present, the radar data is written over area fills of the chart, but below lines and point features;
- the priority of chart data is carried out by the single action control 'remove radar'.

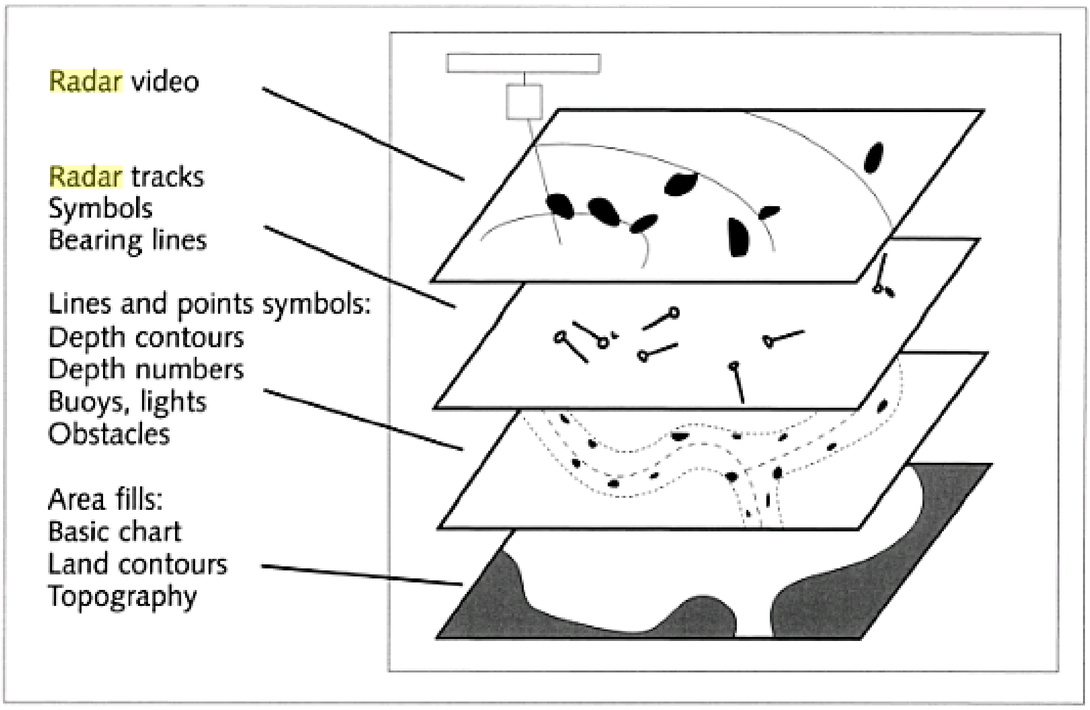


Fig. 30.1: An 'Electronic Chart Multi-layer Object Structure' is used for overlaying electronic chart, radar-video and ARPA target data and for defining the priority of display.

Performance Features and Limitations

The radar image has improved considerably over the last 20 years due to a variety of factors including:

- 'Daylight radar' (e.g. digital signal processing, raster-scan technology);
- Improved discrimination (small digital distance/bearing increments, more pixel);
- Improved clutter reduction (e.g. through scan-to-scan correlation);
- Automatic target tracking (Automatic Radar Plotting Aids; 'ARPA').

However, several shortcomings are still present:

- Limited accuracy and discrimination capabilities;
- Constrained range by such physical factors as power, radar, radar horizon, rain, snow;
- Poorly reflective targets (e.g. small targets, wooden vessels);
- Complicated operation due to many functions with which to be familiar.

The accuracy and discrimination of radar depend on the selected range scale, pulse length, horizontal beam width, and fineness of digitization, screen resolution and operational settings (e.g. Fast Time Constant/FTC'). In short range scales (below 1.5 nm), this can be of the order of 10m – like ECDIS. Any distortion will result in a small shift of a radar target position in comparison with the corresponding ECDIS object.

Advantages of a Radar Overlay

The main benefit of the radar overlay is the display of navigational objects and target vessels on the electronic chart. This way, the integration of chart-related and vessel traffic information on a single display (ECDIS) provides all the information necessary for navigation and collision avoidance. The integration of ECDIS and radar offers a number of significant advantages which are summarized in Table x.x as shown below. In most instances, the integration of ECDIS and radar offers improved overall situational awareness. The traffic situation is easier to comprehend, shipboard decisions are easier to make, and the workload of the Watch Officer is significantly reduced since all essential information is located at one workstation. Altogether, this increases the safety, efficiency and economy of the ship operation.

	Benefits of ECDIS / Radar Overlay
Collision Avoidance	Targets and the area of safe water available for a collision avoidance manoeuvre are readily apparent in one display.
Position Monitoring	The radar image in the ECDIS display serves as a continuous independent position fix. It monitors continuously the primary position fixing system (GPS/DGPS).
Target Identification	Radar targets can be more easily identified when viewed together with charted information. In particular the identification of objects such as ships in the channel, buoys adjacent to the channel, and vessels lying at anchor is much easier.
Radar Performance	The radar-specified limitations (poor resolution, shading) are minimized. Radar targets lying close together, in narrow waterways, or under bridges can be more easily recognized.
Shifted Objects	The set of navigation buoys (the direction of the current flow or the off-place of a buoy) can be determined by comparing their actual (radar) and charted (ECDIS) position.
False Fareway Detection	Ships travelling on the wrong side of a traffic separation zone (TSZ) can be recognized as such.
Error Detection	Errors caused by different reference systems and sensor data (e.g. north orientation of both ‘images’, course differences, speed through the water or over ground) can be more easily recognized on an integrated display.
Mutual Check	The overlaid ECDIS and radar images serve to verify one another. As long the relevant symbols correlate with each other, the functional efficiency of ECDIS and radar is achieved.
Reduced Errors	Human errors (e.g. when transferring information from one system to another) are reduced.
Reduced Workload	Radar bearings and distances need not be manually entered on a chart. The Watch Officer is relieved of this and other routine work.

System Redundancy	Flexibility and redundancy of the two systems (i.e. ECDIS and radar) are enhanced.

Table 30.2: Essential benefits of integrating electronic chart and radar information.

Because relevant objects appear both on the electronic chart and on the radar overlay, they can be compared directly with each other. If a dark green radar paint does not correspond with any object on the electronic chart, it is immediately interpreted as a ship or another object which means a potential danger to the own ship and requires special attention.

In practice, the ECDIS radar overlay provides a continuous and easy-to-use radar fix. If the two pictures were rotated against each other, a gyro error would become apparent. Generally, differences between chart and radar image provide a chance to detect errors which otherwise might not have been detected at all.

The overall advantages of the ECDIS-radar overlays have been quickly recognized by Mariners. However, it should be realized that there are some problems associated with the integration.

30.3: Ground or Water Referencing of the Ship Movement

For ECDIS, course-over-ground (COG) and speed-over-ground (SOG) should be used in order to display the movement of own-ship in relation to charted and geo-referenced objects. This applies also to the vectors of other vessels in the ECDIS radar overlay. On the other hand, the classical radar school of thought requires that the vessels' course and speed should be taken as 'through-the-water' for collision avoidance. This is required in order to make a decision to maneuver based on the movement of two vessels in a moving medium (water). In particular, the ships' 'aspect' should be displayed on the radar screen. A typical situation is illustrated in Fig. 30.3 (below) where two ships approach each other on an opposite course.
In this respect, the radar overlay creates a certain conflict. Only ground referencing is suitable for ECDIS, whereas water referencing provides the correct 'aspect'. It appears to be gradually accepted that, after weighing all pros and cons, the over ground display of the ship movement is more advantageous also for the radar image itself. However, the Watch Officer should have the option to choose the preferred referencing mode.

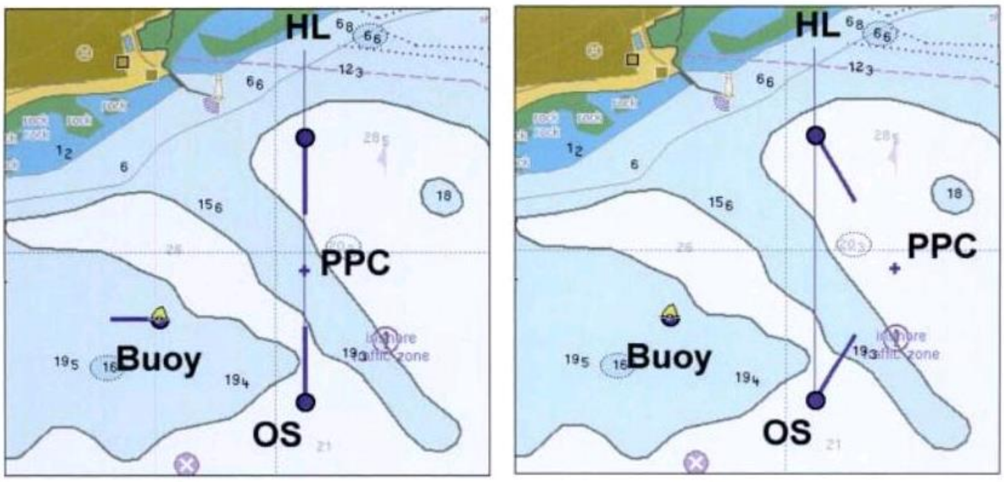


Fig. 30.3: The problem of stabilization of radar data in an electronic chart. A scenario with two ships on opposite courses with an easterly cross current. True vectors, a) Water referenced display (left), b) ground referenced display (right). HL = heading line of own ship; PPC = potential point of collision.

30.4: Radar Overlay Display Modes

You can select from the following presentation modes with the radar overlay:
ECDIS only: Only chart is displayed on the ECDIS.
ECDIS and radar: With S57 chart material, the radar echo image is mixed into the chart so that some chart features lie above or beneath the radar image. This presentation follows the drawing rules of the Standard S52ed3.1 of IHO.
If you use the ARCS chart material, the radar image is drawn on top of the chart.
Radar over chart: Radar echo image is drawn on top of the chart.
Radar video only: Only radar echo image is drawn on the ECDIS display.

30.5: Activating Radar Overlay on the ECDIS

Radar overlay can be output to the ECDIS and shown on its display. Like details on Vector charts (S57), the radar overlay can be displayed or removed from the chart display.

30.6: Adjusting Radar Overlay (Radar Overlay Dialog Box)

The Radar Overlay dialog box has controls for adjustment of the radar image - gain, sea clutter, rain clutter, interference rejector, echo stretch, and noise rejector.
.

Gain control is used to set the sensitivity of the radar echo image. When you adjust the gain, "Noise" is automatically switched ON in order to display low-level radar images.

Sea Clutter control removes sea clutter from the radar echo image.

Rain Clutter control removes rain clutter from the radar echo image

30.7: Choosing Source of Radar Overlay

- **Radar Overlay Through LAN from Radars**
- **Radar Overlay Through Radar Overlay Card Inside ECDIS**

30.8: Controlling Video Processing

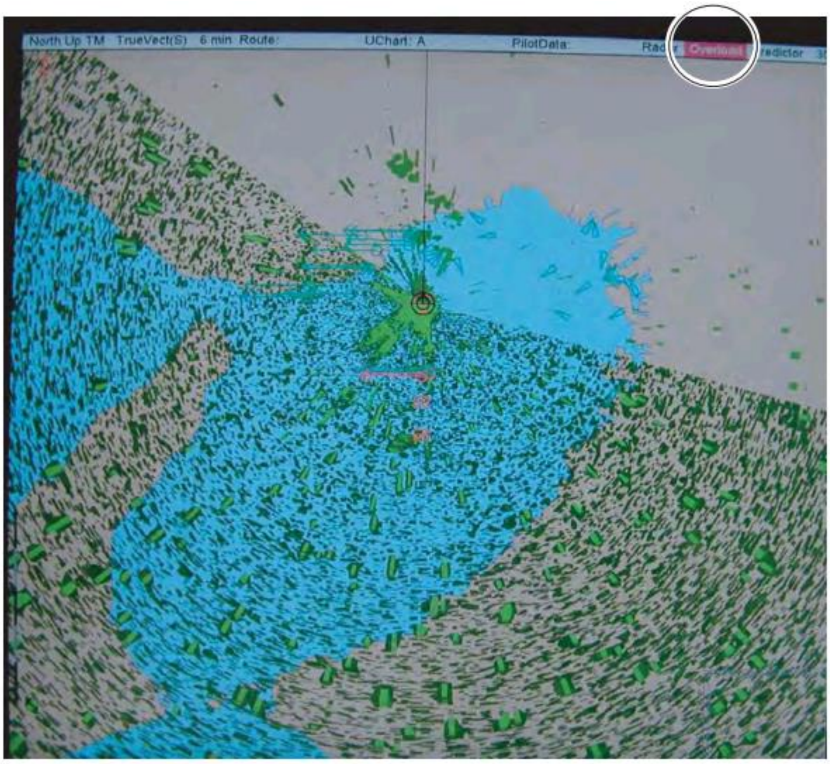
Echo average: You can turn echo averaging on or off. Scan-to-scan correlation averages echoes over successive picture frames to distinguish real target echoes from sea clutter. The choices are EAV1, EAV2, EAV3 and OFF.

EAV1: Helps distinguish targets from sea clutter and suppress brilliance of unstable echoes.
EAV2: Distinguishes small stationary targets such as navigation buoys.
EAV3: Stably displays distant target.

Interference rejector: The interference rejector suppresses mutual radar interference that may occur in the vicinity of another shipborne radar operating in the same frequency band. Three options are available: OFF, IR1 and IR2. Select suitable level to reduce interference from other radars. Select OFF when no noise exists, so as not to miss weak targets.

Echo stretch: Echo stretch emphasizes radar echo to increase detectability of targets. "ES1 / LOW" emphasize both noise and target level echoes while "ES2 / HIGH" emphasizes only target level echoes.
Clean: Removes noise from the screen. Select LOW or HIGH according to amount of noise. Select OFF when no noise exists.

Echo Overload Condition
When the capacity of the CPU is exceeded and there are many targets and sea clutter on the screen, the CPU can no longer process the entire radar image. When this happens, visual distortion occurs and the warning "OVERLOAD" appears in red at the top of the screen.



When the overload condition occurs, you may do the following:

1) Adjust controls (gain, sea clutter, rain clutter, interference rejector, etc) on the radar to obtain proper radar image.
2) On the radar overlay dialog box, you may do the following:
    a) Set IR to IR1.
    b) Set Clean to LOW.
    c) Adjust the Gain control to properly set the gain.

30.9: Error Sources of Radar Echo Image and Chart Display Mismatch

There are several reasons why the radar echo image and chart display do not match exactly. The mismatch is a combination of several reasons and removing one reason doesn't solve the mismatch perfectly. There is a fundamental difference between the radar echo image and corresponding chart feature. The radar echo is a reflection from the real life target and the actual position of the real life target is the front edge of the radar echo. Therefore, the radar echo should start from the chart feature and existed as far as the radar pulse length goes.

Bearing error sources:

1. Gyro
2. Inaccurate chart
3. Improper installation parameters (radar overlay bearing offset)

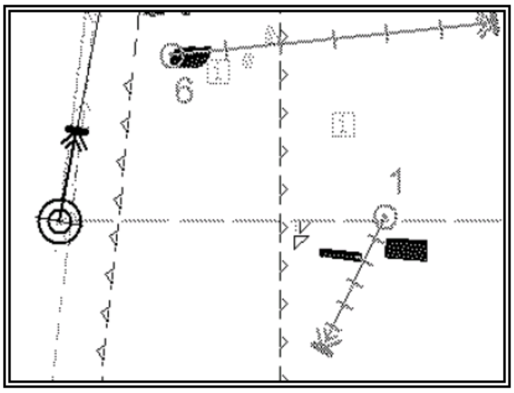
Position error sources:

1. Inaccurate position
2. Position offset

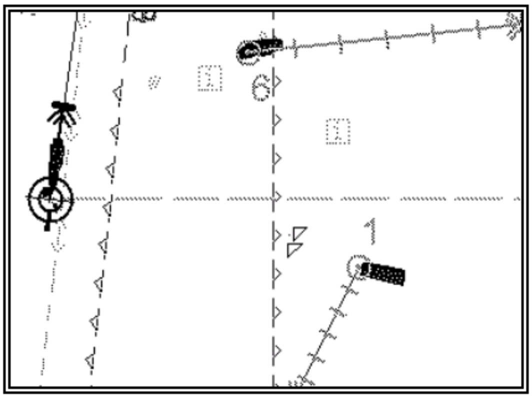
3. Inaccurate chart
4. Wrong datum
5. Datum offset with ARCS material
6. Improper installation parameters (conning position offset, position receiver antenna offset, radar overlay range offset, datum selected for position receiver)

Error Sources of Radar Echo Image and ARPA Target Mismatch
There are several reasons why the radar echo image and tracked target symbols do not match exactly.
1. Different gyro value at radar display and at ECDIS.
2. Improper installation parameters (radar overlay bearing offset, radar overlay range offset, conning position offset).

The example below shows how different gyro value set at radar display and at ECDIS affect the display of the ECDIS.



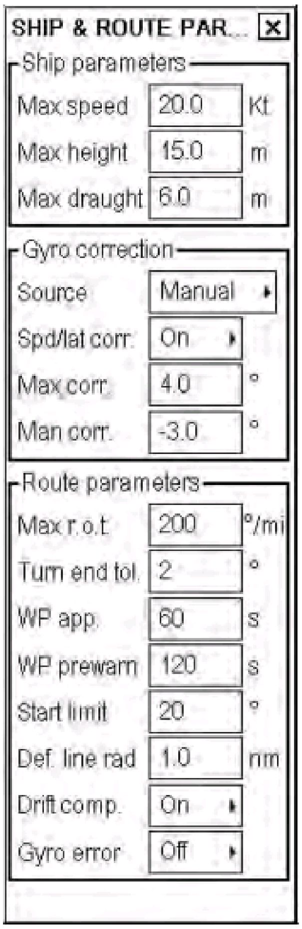
Different gyro value at radar and ECDIS

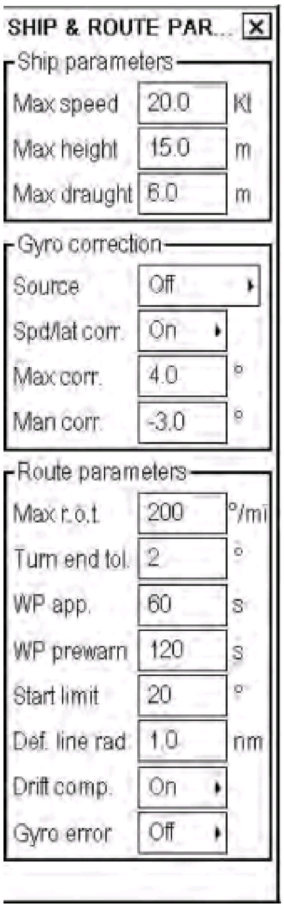


Equal gyro value at radar and ECDIS

Compensating for Bearing Error
There are two ways to compensate for gyro-induced bearing error:

1. Manual
   - Adjust value of manual gyro correction.
2. Table-based gyro speed/latitude correction (Note that the ECDIS's built-in correction facility doesn't correct dynamic error, settling time after course change, etc.)





No manual gyro correction
- ARPA Targets and radar overlay match perfectly.
- Chart features and radar overlay have some mismatch.

Manual gyro correction in use
- ARPA Targets and radar overlay match perfectly.
- Chart features and radar overlay match perfectly.

Compensating for Position Error

➢ Verifying Position and Alignment

If the radar echo targets' symbols are not positioned correctly, there is either position error or gyro error or some combination of these errors.

Position may be aligned on the ECDIS display by moving your ship's position or by moving Tracked Target's position. Moving is done by dragging and dropping your ship symbol or Tracked Target to desired location. Drag and drop means that you place the object on desired location by rolling the trackball while pressing and holding down the left mouse button then "anchoring" the object by releasing the left mouse button.

♦ **Position alignment can be set and restet.**

➢ **Verifying Correct Datum Used in Positioning**

It is very important that output co-ordinates of a position device is the same as the ECDIS expects to receive, otherwise you may get incorrect position in the ECDIS. Verify in position device configurations that output of coordinates is WGS-84 and also check in the installation parameters of the ECIDS that it is set to receive position in WGS-84 datum.

Comparison of ARPA/ATA and AIS data for anti-collision purposes

	ARPA/ATA radar derived data	AIS/VHF derived data
Overall accuracy	Similar to AIS at close range but accuracy reduces linearly with range, due mainly to bearing accuracy	Positional errors 10-30 meters
Framework for calculation	Relative to ship	Ground based
Derivation of aspect	Derived by calculation and depends on accurate knowledge of own ship's course and speed through water	Obtained directly from compass of target ship (when available)
Detection of changes in target course and speed	Takes several minutes	Immediate (when compass available), as soon as gyro starts to change. Otherwise will be apparent when ground track changes
Identification of target size	Can be misleading Changes with range and aspect	Good, if static data is transmitted
Reliance on other equipment	All necessary equipment on own ship Requires compass and log	GPS System Sensors on other vessels Programming on other vessels
Reliability of detecting other vessels in the vicinity	Dependent on echo strength and weather conditions	Only if fitted with AIS Not significantly weather dependent
Target swap	Possible	No
Interference and false echoes	A possibility	Unlikely
Reduced coverage due to own-ship obstructions	Can occur depending on aerial position	Unlikely
Reduced coverage due to land mass obstructions (the 'fjord' effect)	Yes, line of sight only	Unlikely

Range	Typically 10-20 miles, depending on aerial heights and environmental factors	Typically 20-40 miles, depending on aerial heights and environmental factors
Transmission and target response density causing overload	Unlikely	A possibility

30.10: Radar Overlay Related Alarms (Example only)

Alarm Number 6100: RADOV NO HEADLINE
No Headline available for Radar Overlay

Alarm Number 6101: RADOV NO AZIMUTH
No Azimuth available for Radar Overlay

Alarm Number 6102: RADOV NO TRIGGER
No Trigger

Alarm Number 6103: RADOV NO VIDEO
No Video

Alarm Number 6104: RADOV NO GYRO
No heading reference available for ARPA processor

Alarm Number 6105: RADOV HW FAILURE
Radar overlay hardware failure

Alarm Number 6106: LAN RADAR CONNECT STATE
Indication while LAN connection for ARPA features is established between ECDIS processor and ARPA processor

Alarm Number 6107: LAN RADAR CONNECT FAILURE
Failure to establish LAN connection for ARPA features between ECDIS processor and ARPA processor

Alarm Number 6108: LAN RADAR DLL FAILURE
Failure inside ECDIS processor between DLL interface SW and ECDIS software

Alarm Number 6110: RADOV CONNECT STATE
Indication while LAN connection for Radar Echo data is established between ECDIS processor and ARPA processor

Alarm Number 6111: RADOV NO ECHODATA

Failure to receive radar echo data

CH. 31: PROCURING & INSTALLING CHART DATA

Theoretically a chart can be coded for use on a computer as raster or vector chart. Vector-coded charts are coded using a variety of techniques. One technique is called S57ed3 and it has been selected by IMO as the only alternative for SOLAS compliant electronic charts. If an S57ed3-coded chart is published by a government authorized Hydrographic Office, then it is called “ENC”. If an S57ed3-coded chart is published by a private firm, then it is called “NON ENC”. Another vector coding technique is known as CM-93/2, and it is employed by the private firm C-MAP. All CM-93/2 charts are NON ENC.

An ENC could be encrypted to prevent unauthorized use so the user needs a permit to view the ENC. This permit could be entered manually from the control head or control unit, loaded from a floppy disk or loaded through telecommunications from an RENC.

Before any ENC can be used in the ECDIS, it is loaded into your hard disk and converted into the system’s own internal format (SENC). Some parts of the charts may be date dependent, i.e., they are visible after a set date or they are visible only for a limited period, etc. In the electronic chart system, you control all date-dependent objects with Display Until and Approve Until dates. In the paper chart world, the Preliminary and Temporary Notices to Mariners represent the date dependency described above for S57 charts.

An important part of ENCs are the updates. Hydrographic Offices can issue two kinds of updates:

- Incremental updates, which are small additions to original Base cells.
- Reissues and new editions, which are complete replacements of previous Base cells and their updates.

All updates are date stamped and they may also contain date-dependent parts. You control usage of updates in the electronic chart system from Display Until and Approve Until dates. Using Display Until and Approve Until dates, you can view your charts correctly drawn on any date in the past or in the future.

Chart material will be stored in media such as CD ROMs and floppies, electronically through telecommunications from RENCs or electronically from LAN (Local Area Network) in which it could have arrived from RENCs, CD ROMs or floppies. Such material can contain only basic cells, cells and updates or only updates. The electronic chart system contains as standard the software required to access CD ROMs, floppies and LAN.

Each S57 chart may contain additional links to textual descriptions or pictures, besides the chart itself. Typically additional textual descriptions and pictures contain important sailing directions, tidal tables and other traditional paper chart features that do not have any other method to be included into the S57 chart. This ECDIS copies these textual descriptions and pictures into its hard disk so the user may cursor-pick them for viewing purposes.

Vessel need to have license and permit from the distributor to install and use these charts (cell) onboard. Permit has validity of 1-year (max), 9-months, 6-months or 3-months (min) time period. Vessel normally procures ENC data from Regional Co-ordinating center RENC for ENC distribution. RENC validates the data and manages ENC distribution through appointed resellers.

Once the permits have been successfully loaded into the equipment, the licensed chart base data can be installed, normally supplied on CD/DVD-ROMs. Obviously, unencrypted data does not need a permit. It can take a surprising amount of time for an ECDIS to load new ENC data. On some older systems this can run into a number of hours if a big folio is being read from scratch. It is normally quicker to load SENC data but since base data only has to be loaded occasionally, this is generally not an issue. It is good practice to load base data when the ship is on port as it can disable the normal operation of ECDIS or slow it down considerably. It is also a distraction for the OOW if base data is loaded when underway.

Base data is normally supplied every 6-8 weeks and need to be loaded onto the ECDIS before using update supplied along with the base data base charts. Normally all updates are cumulative, hence only the latest update disc requires to be loaded and would apply for all past updates. The base data, even from a single source such as the UKHO, can consist of many disks. It is important for the mariner to read the accompanying instructions carefully as they are often required to be inserted in a specific order. There is commonly a ‘Readme’ file on the base data disk set that may contain additional information.

31.1: WEND: The Organizational Framework for International ENC Distribution

The distribution of ENC’s means making the ENCs produced by HOs available to the marketplace in a way which allows the user to obtain data for his ECDIS for world-wide navigation. This is the basic requirement for every HO, and some HOs do only this, e.g. by putting ENCs (and updates) on the internet. The user then may check the various HOs directly, but this becomes prohibitively cumbersome if the user is engaged on international voyages. Therefore service providers have been established which collect the ENCs from different HOs and maybe other sources, to deliver to the end user all data he needs for his voyage.

A particular problem is to ensure that all official ENCs produced by a large number of different HOs are of the same quality. The standards relevant to ENCs, as complex as they are, necessarily leave too much room for interpretation and judgment so that there is no automatic way for a worldwide harmonization of ENCs in terms of content and presentation. Without an additional intervening mechanism ensuring uniform data quality, Mariners would be left with inconsistencies between ENCs from different HOs. This is the background why IHO has developed a concept for a worldwide official ENC service.

Uniform and direct – the principles of the ECDIS service
The concept of an official ECDIS data service was developed in conjunction with the IMO requirement to establish a worldwide uniform updating service. The necessity of providing timely reliable updating service – throughout the world – is a major organizational challenge for national Hydrographic Offices. Another challenge is the need for the updates to reach the ships by the quickest possible method, regardless of whether they are in port or at sea.
The fundamental requirements for an official ECDIS data service include

- Global uniformity of data:
  All participants must work in accordance with the same standard, i.e. the S-57 data transfer standard. It must be ensured that ENCs from all producing HOs worldwide exhibit a consistent content and display.
- Quickest way from the source to ECDIS
  This excludes any additional levels of processing. That is why the data must come directly from the originators. The Hydrographic Offices must have strict sharing of work in close co-operation. This ensures at the same time the global uniformity of data.

Ideally, there should be one overall organization to keep the official ECDIS data service functioning. A new international organization could be established for this purpose, but this can be a lengthy process. An alternative could be that an existing hydrographic service (e.g., British Admiralty) could take over this function. However, many nations feel this to be a national responsibility and consider a single ENC producer not internationally acceptable.

A reasonable solution is to have an arrangement for sharing the work of setting up and facilitating the provision of a world-wide ECDIS data service based upon agreed upon standards. This arrangement was established by the IHO as the **World-wide Electronic Navigational Chart Data Base (WEND)**.

WEND: A Charter and an Organizational Concept
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 term 'integrated services' means here 'a variety of end-user services where each service is selling all its ENC data, regardless of source, to the end user within a single service proposition embracing format, data protection scheme and updating mechanism, packaged in a single exchange set'.
WEND consists of two components to achieve its purpose:

- A charter describes the principles governing the co-operation. This includes (inter alia) the following provisions:
  - By definition, the organization responsible for hydrographic survey of an area is also responsible for the ECDIS data;
  - the relevant ECDIS standards, especially S-57 Edition 3 must be observed;
  - the rules and responsibilities for producing and validating the data.
- So-called Regional Electronic Chart Co-ordinating Centres (RENC) which 'are organizational entities where IHO members have established co-operation

amongst each other to guarantee a world-wide consistent level of high-quality data, and for bringing about co-ordinated services with official ENCs and updates to them'. Hence, a RENC takes over the responsibility on behalf of its members for the final quality-assurance of the ENCs they are contributing (including their updates), and for the establishment and operation of official ECDIS data services.

WEND has to provide for the necessary interface to service supply and data distribution. While WEND is based on government authorities consisting of HOs and RENCs, the service sector is not regulated and considered a commercial activity normally left to private companies.

Thus, WEND is the IHO concept, based on the co-operation between Hydrographic Offices, for facilitating the establishment of ENC-services intended to satisfy the SOLAS carriage requirement for official, up-to-date charts. Although the framework of the International Convention which forms the principles of existence and work of the IHO is really not adequate for an operational service like WEND, the expense of setting up a new organization is simply too high and the process too lengthy. Thus within the IHO, the WEND concept is being implemented through regional or bilateral co-operation arrangements between Hydrographic Offices. The agreed concept defines the responsibilities and functions required to develop, quality-approve, and issue the official ENCs for the use in ECDIS including the required updating services. These co-operative arrangements constitute basically what is called 'RENCs' in the WEND conceptual model, and may vary from region to region or country. They can be regarded as an extension of the co-operation between HOs set out in the IHO Convention, with the specialization on ECDIS-related services.
The WEND principles define the responsibilities of hydrographic offices, including:

- The preparation and provision of digital data and its subsequent updating for waters of national jurisdiction;
- Ensuring that mariners, anywhere in the world, can obtain fully updated ENCs for all shipping routes and ports across the world and that the hydrographic office's ENC data is available to users through integrated services;
- Assuring the high quality of ENC services through the use of a Quality Management System that is certified by a relevant body as conforming to a suitable recognized standard; typically this will be ISO 9001;
- Ensuring compliance with all relevant IHO and IMO standards and criteria; and
- Providing timely updates to the ENC for the mariner; these should be at least as frequent as those provided for the correction of paper charts.

31.2: RENCs: THE SUPPLY OF DATA SERVICES

♦ **World's First RENC in Stavanger (Norway): the RENC Northern Europe (PRIMAR)**

The initiative to create the world's first RENC came from the Norwegians back in 1990 when they announced their intention of setting up an ECDIS data center in Stavanger under the name of the Electronic Chart Centre (ECC). The IHO allocated the area of Northern Europe to the ECC. Later on, the ECC was turned into a private company owned by the Norwegian government.

Considering the lack of practical experience, as well as the then unfinished process of ECDIS standardization, it was a rather courageous initiative. The fact that the standardization took much longer than expected (it was concluded in practice only in 1996) made the costs too high for Norway to continue alone. As a result, the British Admiralty Hydrographic Office joined the ECC as a partner in 1995. Until July 2002, the RENC was conducted as a Norwegian-British joint venture.

The co-operation between hydrographic offices on issuing ENCs has been formally established through a bilateral agreement between UK and Norway as Operators, and a ‘Co-operation Arrangement’ (COA) between the Cooperating HOs (CHOs). Generally, a COA can be considered a type of a Memorandum of Understanding (MOU) between government agencies. It is usually open to accession for any other country’s national agency. Although in the strict legal sense non-binding, it has proven to be an efficient, easy-to-use approach to implement the mutual obligations of co-operating within a RENC, and to define a suitable common management structure (e.g. an Advisory or Steering Board).

Data have been made available in S-57, encrypted using a security system developed by the RENC/NE which became known as the PRIMAR encryption.

♦ **Two New RENCs Take Over in 2002 From the RENC/NE**

The COA of the RENC Northern Europe excluded sharing any financial risks by the CHOs. The financing of the set-up and the running costs remained entirely with UK and Norway as the operators. During 2001 it became evident that this arrangement was still likely to bear for a longer period unacceptable financial strains for the operators, so that a different financial structure was needed in which the Cooperating HOs also would have to contribute somehow to the costs of the RENC operations. It proved difficult to reconcile different models of getting CHOs to share the set-up and operating costs of the RENC so that finally two separate RENCs were established in 2002 to continue the RENC/NE services from July 2002 on:

- PRIMAR Stavanger™ (www.primar.org), operated by the Norwegian Hydrographic Office. Its cost share model is based on direct payments for the services provided by the RENC. This results in net payments as long as the share of a CHO in the costs of the RENC operation exceeds its revenues. The co-operations between CHOs is defined through Bilateral Arrangements between the Operator (Norwegian HO) and the CHOs;
- The ‘International Centre for ENCs’ (IC-ENC) (www.ic-enc.org), operated by the British Admiralty. Its cost share model for covering the set-up and running costs is based on a fixed fee subtracted from the sales revenues for ENCs owed to CHOs. The fixed fee will be lowered when eventually all set-up costs are recovered and only running costs have to be recovered. The operational and financial arrangements are to be agreed through Bilateral Arrangements between the Operator and the CHOs. An additional COA defines the multilateral organizational and financial structure of the RENC.

These RENCs are based on different structures. For the IC-ENC, distribution is based on a limited number of large service providers, so called 'Value Added Resellers' (VARs), that are willing and capable to encrypt the data they receive from IC-ENC (and any other RENC or HO), and to provide own-branded comprehensive services including full route coverage, integrating different data sources. The VARs are also supposed to integrate all the available ENCs from other Hydrographic Offices and RENCs all over the world. The new distribution structure is aiming at:

- Promoting the use of ENCs, where they exist, through complementary multi-fuel services, where necessary;
- Facilitating the use of ENCs to the end user through one-stop shopping services for full route coverage.

Information vs. Data

Are data different from information? While in the most basic sense the answer is no, the two terms should not be used interchangeably. There is small but important distinction between information and data. The concept of 'information' describes the knowledge of something – whatever it may be. Information is something that we have in us (knowledge), or what was conveyed to us. In order to communicate information, it must be packaged in a suitable form. Books and maps (or charts) are the media through which an author communicates with the reader to transfer information. The information, itself, is independent of the methodology of transfer. However, when this information is 'packaged' for transfer, the information becomes data (from Latin dare: to give). Obviously, there can be many types of data, depending on medium and on transfer technology.

In this subject, the word 'information' is intended to denote knowledge content, while the word 'data' means information in a very specific form (e.g. format). In this regard, the word 'chart' implies data – or to be more precise – geographic data. Chart data can be either printed paper (e.g. analogue) or electronic (e.g. digital) form. However, the knowledge conveyed by the chart is, by contrast, information. Using this distinction, we can now answer the question about the nature of the electronic chart that was posed earlier. An electronic chart system is not a computer, nor is it a database or a chart image displayed on a monitor. Instead, it is the system as a whole (hardware, software, and database). The computer is needed to store, process and display the data. In contrast, the medium of paper in the paper chart serves both purposes, that of data 'storage' and of display.

How the data can be used depends on how it is structured and organized of it (i.e. the way it is 'packaged'). In this regard, there is a need to understand the various types of data. In the process, it should become evident how computers overcome the restrictions of the paper chart.

Digital and Analogue Data

The rapid processing of data by a computer is possible only for digital data (i.e. data encoded in discrete numbers). Digital data is the only type of data that today's computers can 'understand' or use. All information stored on a computer has to be converted into numerical form. This applies not only to numbers, text, pictures, music, but also the programs that enable the processing of data to occur in the first place. On the other hand, the reproduction of information through the media that enable a continually variable (e.g. step-less) presentation is called analogue. This includes such things as sound (speech), images (color, brightness), and printed or written words. In contrast, a digital presentation is defined (and limited) by the discrete numerical steps. For example, whether or not a statement was handwritten or created on a computer, printing it on a sheet of paper makes it an analogue presentation. However, the exact same text stored on the computer or copied to a diskette, results in a digital representation, even if it actually had been scanned from paper.

31.3: Data Encryption

The risk of illegal copying and intentionally corrupting data has grown immensely particularly in today's digital world. ENCs, on one hand, represent a commercial value both to issuing HOs and to providers of ENC services and, on the other hand, are also digital documents the contents of which have to be protected against falsification and data corruption in the interest of safety of navigation. Therefore, already the first ENCs produced and distributed by the then RENC Northern Europe had been made subject to a data protection scheme.
Such a data protection serves a threefold purpose:

- Prevent data from illegal copying;
- Authenticate the origin of data, i.e. prove that the data is all from the original (official) source;
- Provide for a selective data access, i.e. allow only access to those data the user is permitted to under license.

The methodology consists basically of *encrypting* and *signing* the data.
Without going into any technical details, one can say that both encryption and signature represent a technique of altering the digits contained in the digital file in a way the reader cannot decipher, unless he obtains additional information ('keys') that reverses the previous changes applied to the digits and restores the data in its original form.

Roughly speaking, encryption can be described as applying to the data general key so that it can only be deciphered if one possesses a personal key fitting exactly to the above general key. This personal key is used to decrypt the data into its original form. This personal key may be the same key as the one used for encryption (symmetrical key). For asymmetrical keys, also referred to as 'public key methods', the key used for encrypting the data is even to be published, but a different key, uniquely fitting to the public key, is needed to uncrypt the data; this key is a secret key provided only to e.g. licensed persons. Digital signature is always based on an asymmetrical key and in a way, the reverse procedure: The data is 'signed', i.e. encrypted, with the private (secret) key of the data supplier and can be decrypted using a published key uniquely identifying the source of the data. If the public key works with the signed data, it proves ('authenticates') that the data is indeed from the expected source. The encryption process not only provides the basis of a licensing mechanism, but it also ensures the integrity of the base data. Unencrypted data can be copied by unscrupulous companies and sold on, even though it may be out-of-date or corrupted, whether purposefully or inadvertently. The permit is normally specific to an individual ECDIS or to a group of ENC-using equipment on the ship – for example, all ECDIS and chart radars. It means that the permit has to incorporate equipment identification data. The equipment identification data embedded within the permit actually forms part of the encryption process and so a user cannot simply change the data to make it accessible by different equipment.

Data protection is, in principle, a technique of applied number theory. A variety of different methods exists. The method originally developed by the former RENC Northern Europe, is based on the ***'Blowfish Algorithm'***, a public domain method. It has been adopted in an extended way by IHO Membership as the IHO Data Protection Scheme in 2002 S-63 [IHO S-63, 2002]. In that publication one will also find all other details of the very complex processes involved in protecting the data.

31.4: Data Loading

Loading S57 Charts from a CD ROM, Floppy Disk or LAN
When you load S57 charts by CD ROM catalogue, the system first loads a CD ROM catalogue, which stores certain information into your hard disk such as cell IDs, their position, and edition number, from your LAN (Local Area Network) connection, floppy disk or CD ROM. Then, the system asks which charts you want to load from the selected media. After building the CD ROM catalogue, you can view the contents of it using the Chart Catalogue command in the Chart menu.

Note: All CD ROM's floppies or LAN (Local Area Network) connections from one single National Hydrographic Office have the same name although their contents could be totally different. You can use your own unique names to identify them separately and correctly later.

Interpretation of Load or Update Charts from Loaded CD ROM Window
This window provides information about the loaded CD-ROM.

31.5: Procurement

There are different means of procurement for the Paper Chart System and Electronic Chart System. Paper charts are only purchased once, until a new edition is issued; by contrast electronic charts are purchased through a license system.

Vessels on liner routes normally only carry on board the paper charts for their particular service, whereas vessels engaged on worldwide trading usually carry a portfolio of charts covering most areas of the world.

With electronic chart data, all charts are already on board, but use can only be made of those for which licenses have been activated. When a change of route is made, the navigator consults the digital chart catalogue, supplied as part of the chart folio for the charts required. The chart cells for the forthcoming voyage can be activated almost immediately by purchasing the license to activate them, usually by sending an e-mail to the chart provider.

Different suppliers have different ways of licensing chart cells. Most licenses are sold for a 12 month period and the owner/operator then has to renew them for a further 12 months. This has proved a barrier to the take-up of ENCs, as owners had to purchase licenses to be purchased for chart cells even if the vessel only used that chart once in the 12 month period. However, most suppliers now allow licenses to be purchased for periods of three, six, nine or twelve months, reducing the outlay required by the owner.

❖ **PERMITS**

The data for the vast majority of electronic charts, including ENCs, RNCs and private data is encrypted. In order to read the licensed data a *permit* that enables the use of the data must be input into the ECDIS before decryption can take place.

Permit keys are generally in alphanumeric form to allow human transcription as well as computer recognition. This means they can be sent to the ship in a variety of different ways, for instance, by being provided on CD-ROMs or floppy disks that can be directly loaded into the ECDIS. They can also be sent in email, normally as an attached file. It is then usual to copy this data to a disk or to a memory stick for application to the ECDIS, depending on its capability. If the permit key is short, for instance, if it covers just a few cells, it should be possible for the data to be manually entered into the ECDIS via its keyboard. On some ship installations, it may be possible to transfer the permits electronically through a network connection to the ECDIS. This is not recommended unless full attention has been given to system virus protection.

Since data can come from multiple sources and in different formats, it is possible that multiple permits have to be loaded. The correct menu item should be selected on the ECDIS, according to how the data has been received, and the on-screen or user manual instructions followed. Messages displayed on the ECDIS should alert the user if a problem is encountered, with some indication of its nature.
The permit needs to be loaded in a number of circumstances for instance:

- When the ECDIS is newly installed
- When more charts need to be added to the ship's outfit
- When loading charts from a previously unused source
- When the permit has expired
- Whenever a data supplier sends a new permit (often when new editions of charts are issued).

The equipment identification data, sometimes called the *User Permit*, is provided originally by the ECDIS manufacturer to the ship operator, a copy of which should be carried on the ship in case emergency data has to be procured from a different supplier. Once the identification data has been supplied to the data supplier, it will be stored indefinitely by them and should not need to be resent. And in case, if any of the equipment that reads chart data on the ship is replaced, the chart supplier needs to be given the new identification data.

The permit, as well as covering specific charts or areas, has an associated license period. This is commonly one year although three-monthly licenses are becoming more common. More sophisticated licensing schemes are emerging that are more dynamic and it is likely that this area will continue to evolve into the future. For instance, it may become common for the fee to be based on the actual use that has been made of charts during a particular voyage.

If there is a problem with the permit or the permit-loading process, the system will give a message such as *permit not valid*, possible with more detailed information concerning the problem and chart data will not be able to be loaded. When a permit is about to expire a warning will normally be given, generally several days in advance. When actually expired, there will normally be a permanent indication on the display that this has occurred. However, it should still be possible to view all charts and updates that were loaded prior to expiry, although on further updates will be permitted by the system. This means that a dangerous 'blackout' of chart data will not occur just because of permit expiry. Nevertheless, there are also obvious dangers in using out-of-date charts. Importantly, the system will not meet the chart carriage requirements specified by IMO in SOLAS. The situation should therefore be rectified urgently.

Permits are used to control the permission to use a chart. A permit in RENC security is connected to an edition.
Permits are issued as two different types:
- **Subscription permit.** These include updates for subsequent 12 months. It is assumed that a typical user is a SOLAS class ship, which is required to use up-to-date charts.
- **One-Off permit.** These include only updates up to the issue date of the permit. It is assumed that a typical user is a non-SOLAS class ship, which is not required to use up-to-date charts.

Each permit also includes the expiry date. The expiry date of a permit controls the ENC to SENC conversion. If the issue date of a chart or update is older or equal to the permit expiry date, then the system can convert an ENC into the SENC. There are no viewing time limits as used in some other security systems such as ARCS. The user has a right to view a chart forever and more over he has a right to convert a chart from its ENC format into the SENC forever.

An RENC can issue permits in two formats:
- **"*.pmt" format**. This format does not include the applicable chart edition nor does it include applicable permit type.
- **PERMIT.TXT format**. This format includes the applicable chart edition as well as applicable permit type.

Both permit formats are fully operational, but the older "*.pmt" format creates confusion because it cannot support the user when chart edition changes.

The system display warnings associated with expiry date. Examples are “will expire” warning 30 days before the expiry date and “have expired” after the expiry date. These warnings are relevant only for Subscription permits. Only the new PERMIT.TXT format supports the system to suppress irrelevant warnings associated with expiry date.

Loading an RENC-Generated Permit CD ROM or Floppy Disk
An RENC can deliver permits in a CD ROM or a floppy disk. When you receive new permits from an RENC, you have to load them into the ECDIS. A permit is a key which is used to decrypt the chart you want to use in the ECDIS.

Messages Which May Appear When Loading a Permit

❖ **Base Data**
Once the permit have been successfully loaded into the equipment, the licensed chart base data can be installed, normally supplied on CD/DVD-ROMs. Obviously, unencrypted data does not need a permit. It can take a surprising amount of time for an ECDIS to load new ENC data. On some older systems this can run into a number of hours if a big folio is being read from scratch. It is normally quicker to load SENC data but since base data only had to be loaded occasionally, this is generally not an issue. It is good practice to load base data when the ship is in port as it can disable the normal operation of ECDIS or slow it down considerably. It is also a distraction for the OOW if base data is loaded when underway.

The base data, even from a single source such as the UKHO, can consist of many disks. It is important for the mariner to read the accompanying instructions carefully as they are often required to be inserted in a specific order. There is commonly a ‘Readme’ file on the base data disk set that may contain additional information.

The base data disks should be kept carefully as they may need to be reused. This will occur if extra ENCs or RNCs have to be licensed to allow the ship to navigate in additional areas. It is useful to keep the disks in their original sleeves and boxes for protection and ease of identification. If disks become scratched or dirty they may become unreadable. Also, if they are left in sunlight or close to a source of heat they may become distorted and not readable by the system.

❖ **Authentication**
Normally the authentication process is invisible to the user. Only if the authentication fails, then the user gets an appropriate notice. From a user point of view, the authentication is similar to the CRC checksum test. If the CRC checksum test or authentication fails, then the chart is unusable. Authentication uses a private key and a public key. A digital signature associated with each chart contains a private key. A public key is stored in the ECDIS and it is truly public. RENC may publish a new public key. This public key will be available as text by fax, by post, by front page of a newspaper, etc. and as a text file, for example, PRIMAR.PUB.

❖ **Available Service Types**

CD ROM service

If you are using a CD ROM service, you receive the following from an RENC:

- Base CD ROM contains all Base cells that are available in an RENC CD ROM database when the CD ROM was released.
- Update CD ROM contains all updates to the Base CD ROM, but it will also contain any new Base cells and new edition and re-issues received from the contributing Hydrographic Offices. Update CD ROM will be issued once a week.

If you want to enlarge your chart coverage, you have to contact your distributor to order more permits for new charts.

❖ **Subscription types**

Charts and their updates stored in RENC are decrypted and you have to get a key (permit) to load charts into the ECDIS. There are two different kinds of permits: subscription and one-off.

Subscription

Subscription period is 12 months and it starts when you order first permit(s) from an RENC.

- User subscribes to an updating service
- Updating service has a renewable expiration date
- ENC is still available after expiration, but cannot apply any new information
- User will receive the following during the service period:
    - All updates issued to the ENC
    - Any re-issues for the ENC
    - Any new edition of the ENC

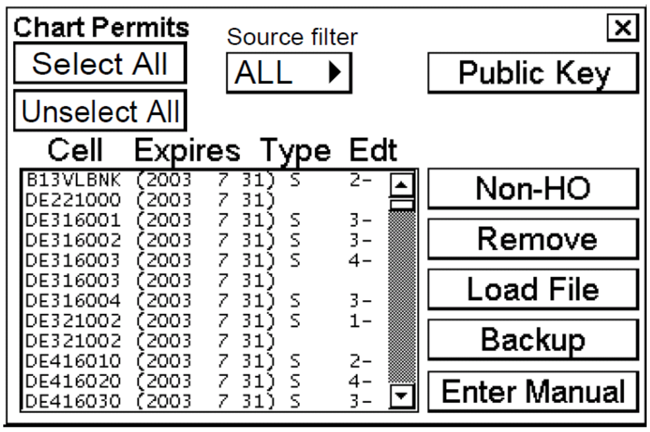
One-Off

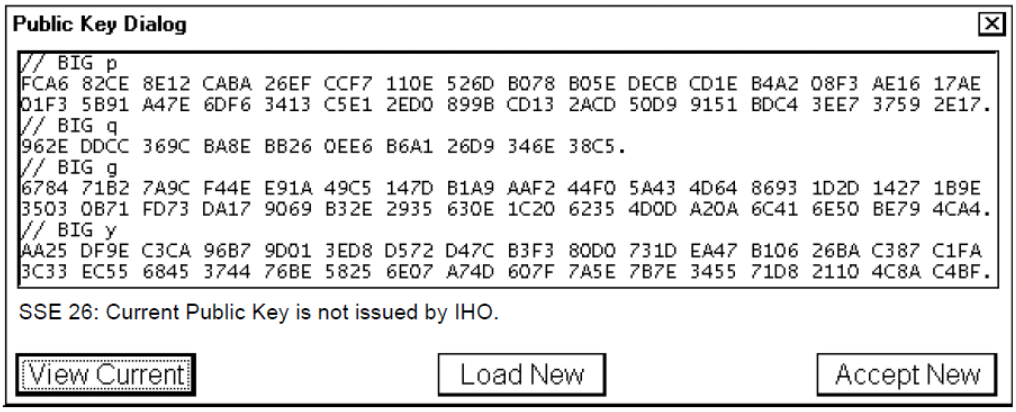
In the one-off permit, you order permit for chart and updates which are valid until date you order permit (i.e., chart is up-to-date when you ordered it). No more information can be retrieved for this chart, which is published after order date.

One-Off Current Edition: Permit for a chart which is based on data on the hard disk of the ECDIS.

One-Off Latest Edition: Permit for a chart which is the latest available based on the Product List of an RENC.

❖ Managing Public Key From an RENC





Compare the content of the newly loaded public key with the known content of the public key of an RENC you use.

CH. 32: INSTALLING CHART CORRECTIONS

Once base charts are installed on the ECDIS, they need to be updated by loading the appropriate update disk. These disks are almost always cumulative, which means that they contain all the update data from previously issued disks, which are normally issued on a weekly basis. Because of their cumulative nature, only the latest update disk is required and not disks of previous updates. However, new editions of base disks are occasionally replaced with totally updated versions – for example once a year. Update disks also contain base data of newly issued cells and of cells that have had to be fully revised before a new base disk set becomes available. The most recent base disks must be input into the ECDIS, as subsequent update disks are unlikely to be able to update data from older edition base disks. The ECDIS will give an error message if an update disk requires data from a revised base disk before the updates can be incorporated.

Although cumulative update disks are normally supplied, *sequential* (non-cumulative) updates are permissible. It is possible that some services direct from certain hydrographic offices may use sequential updates, although update disks from the two major RENCs are cumulative. The ECDIS will warn the user previous updates have not been applied, terminate the update process and restore the SENC as it was before the application of the ENC update file.

32.1: How ENCs and RNCs are 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.

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.

At present most ENC and RNC updates are supplied to ships on CD-ROM but remote updating using satellite (or, when in port, shore based) telecommunications is becoming more and more common. A number of ENC service providers already have updating services using e-mail, the worldwide web and other means. Details may be obtained from ENC distributors.

32.2: 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. In some systems this list can be checked on screen or printed out to check the update status of the ENCs that have been loaded. If ECDIS is not able to show the list, 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 listing function of ECDIS to verify that ENCs are being kept up to date in accordance with SOLAS V Regulation 27.

32.3: Automatic Chart Correction – A Good Reason Why ECDIS is Worthwhile

One of the major benefits of using electronic charts is the ability to automatically update the electronic chart database. It is particularly true for ECDIS which has specific functions and requirements to facilitate the means/process of updating. For instance, shifting the position of a buoy, entering of a new spot sounding, or showing the location of a new jetty in a harbour can be all performed through a wireless transmission of machine readable update instructions to the ECDIS prior to getting underway from a port. Once this process becomes a widely available service, this should significantly reduce the occurrence of out-to-date chart information. Not only will it likely reduce the number of fines, insurance companies may eventually downgrade the costs of the risk coverage. With no loss in operational safety, a navigation officer's workload can now be focused on other shipboard tasks.

32.4: Handling of Digital Update Messages

Digital updates completely replace the corrected chart contents. The update messages carry in their headers the reference to the ENC which is being updated and a consecutive number corresponding to their issue in the series of all updates of that ENC. The update data can be installed only in a complete sequence. If an update be missing in the sequence, the system will reject the later updates with higher sequential numbers. The user himself has no possibilities to reject any deletions, changes or additions contained in the update data. The system offers however a functionality permitting the user to see and confirm every incoming correction. The way of marking the digitally installed corrections is not standardized and can differ between manufacturers.

Each correction is described in detail and saved in the log file. The user can therefore check all the corrections applied to a given ENC at a later date. Digital updates are always related to the objects in a particular ENC and are displayed only with this ENC. The update of an object in one ENC is not automatically carried out on the same object in another ENC covering the same area in a different scale. In this case a separate update file for the same object (e.g. a buoy) is necessary for each relevant ENC, with an appropriate sequential update number for each ENC. The set of the update objects assigned to an ENC will be overwritten when a completely new edition of that ENC is installed. Only the special log file will show the 'update history' of the now overwritten ENC and list which update files were installed and when.

32.5: Methods of Transmission

What sounds simple in theory can often be full of problems in practice. In case of automatic updating, the question is "what is the best way of distributing the update messages?" Regardless of the method of transmission, there are two basic approaches to distributing updates. With a broadcast (or 'push') approach, a ship would periodically receive update messages regardless if it actually needed or plan to use them. Alternatively, a 'pull-approach' involves more of a user requesting first, followed by the distributor sending what is needed. Erica pad

- **Broadcasting Updates**

One option is to broadcast update messages via the 'Enhanced Group Call' (EGC) channel of the INMARSAT-C Service. The EGC channel – being part of the Global Marine Distress Service System (GMDSS) – can be used to broadcast message varies between four and six kilobytes per ENC (chart) per week. Potentially, most ocean-going vessels equipped with ECDIS would carry ENC data covering many ports and regions. However, not all ENC data held by a vessel needs to be corrected simultaneously by an update message. It is generally thought that the total weekly volume of ECDIS update message. It is generally thought that the total weekly volume of ECDIS update messages for a vessel would be from several hundred of kilobytes to one megabyte of data. These amounts of data are too voluminous to be efficiently broadcast via INMARSAT EGC. In this regard, it can be expected that only the most urgent update messages – directly affecting safety of navigation – would be sent over the EGC channel.

Another possible means of sending update messages is to use an INMARSAT service offering a wider bandwidth. The digital INMARSAT-B and INMARSAT-F offers a bandwidth between 9600 bits and 64000 bits per second at reasonable cost. For example: ChartCo Ltd. UK as a provider of maritime data directly to ships at sea is making use of these services. It delivers bulk data by means of a satellite broadcast using the ship's existing Inmarsat A, B or Fleet 77 terminal in conjunction with a dedicated broadcast receiver. There is no interference with normal ship's communications and the data is received automatically. There are plans to apply this service to ENC update distribution in due course.

- **E-mail – a flexible solution**

Another procedure to distribute the chart update information wireless is to use E-mail technology. Chart data distributors like Chartworld are making use of the SKyFile-E-mail service transferring individual data packages to their customers via INMARSAT-B and INMARSAT Fleet 55/77. By means of a special E-mail-account reserved for the reception of ENC and RNC updates the available satellite terminal on board can be used for transfer – without any need for extra hardware. A special software assists the Mariner then to burn the necessary update CDs containing the received data.

Other manufacturers of nautical equipment (e.g. Furuno, maris Maritime Information Systems AS) offer integrated hardware interfacing to GSM mobil phone connectivity to receive updates form a dedicated server by a tailored e-mail protocol.

The method of distribution of the update messages that will ultimately be preferred, is difficult to predict. Certainly, the distribution on CD-ROM and diskettes will be reduced to ships with frequent harbor contact and the supply of the wireless communication services will become more prevalent in the near future as an effect of the expansion of satellite based communication. Most likely, solid data carriers such as a CDs, will continue to play a larger role in the distribution of ENC and RNC base cells. The ever-increasing capability of new and improved communication services will eventually lead to a multiplicity of distribution methods to the customer.

32.6: ENC Updating

ENC updating is the process of producing, disseminating and incorporating the ENC update information in an ECDIS. To accomplish an update of an ENC, updates are applied to the SENC. Issuing a new edition of the ENC, and the reissuing of a version of the current edition ENC which incorporates all changes which have been disseminated as ENC Updates up to a specific date (the equivalent of a "corrected reprint" paper chart), although logically the most comprehensive update operations, are not treated here. ENC Updating involves:

1. **Entities** engaged in processing the ENC update information;

   (a) The following entities are involved in updating:
   i. **Source Provider**: an originator, such as an originating HO, or another information source, such as a local authority, providing navigational warnings.
   ii. **Issuing Authority**: an entity assembling an ENC update data set from update information provided from various sources, and being responsible for setting up the transfer of the update set. By definition, the Issuing Authority is the issuer of the ENC to which the update applies. The Issuing Authority under the WEND system is the Regional ENC Coordinating Centre (RENC).
   iii. **Distributor**: an entity responsible for packaging, repackaging, and/or disseminating an update set to all users, or a group of users.
   iv. **Receiver**: usually the mariner on board ship, or the telecom receiver linked to the ECDIS.
   v. **Applier**: an entity controlling the application of the update information, e.g. the mariner keying in update information, or the software inside ECDIS automatically processing the ENC update information.
   vi. **SENC**: the ECDIS data base to be ultimately updated, and actually being used for data access.

   (b) **Source Provider** and **SENC** are the **primary entities** as they represent origin and target of the updating process. They must always be present. The other entities are called **transit entities** as they perform intermediary functions which are not required for all transfer media.

2. **Physical Media** used to carry the update information;
3. **Update Operations**, chosen by the issuer of the update information and subject to his responsibility, to provide the update information to the SENC in the most efficient way;
4. **Transfer Procedures** of update information, depending on the media and channels used as well as validation procedures required to secure correctness;

5. **Data Base Operations** for incorporating the update information and verifying the updated data base.

❖ **Service Categories**

a. **Scheduled Service**. An updating service at regular intervals known in advance by both the sender and receiver. The dates of transmission can be those agreed upon in a bilateral contract between e.g., distributor and receiver, or a broadcast or mailing schedule of the distributor published in an official publication. There may be customized service modes, such as expedited transfer or direct on-line transfer, which still are considered scheduled as long as they follow a previously agreed schedule.
b. **On-demand Service**. Any updating service at the expressed request of an individual user, e.g. transmission of updates called up by the user in a dial-up session with an official updating data base (another example is the request for retransmission of a missing Update Set). All update supply actions initiated by the user are regarded "on demand" unless the supplier itself relies on strict observation of a previously agreed schedule (and issues a "nil-message" if no updates are available).
c. **Extraordinary Service**. Any updating transmission not following a regular schedule, and not individually requested by the user, such as an extraordinary navigational warning containing urgent ENC-related information.

❖ **Updating Categories**

The updating methods can be subdivided into different categories:

1. Application Categories

(a) **Manual Updating** consists of a human operator entering information manually into the ECDIS, usually based on unformatted update information that is not machinereadable (such as printed NtMs, voice radio, verbal communication etc.). However, in order for the ECDIS to accept manual updates, the update information must be entered in a structured way at least compatible with the relevant ECDIS standards.

(b) **Automatic Updating** consists of an updating process by which the updating information is applied, within the ECDIS, to the SENC without operator intervention. All automatic updating requires the data to be formatted according to the relevant ECDIS standards. Automatic updating can be broken down into the following two sub-classes:

1. **Fully-automatic Updating** is an updating method where the update data reaches the ECDIS directly from the distributor without any human intervention. This may be accomplished through a broadcast transmission, INTERNET, etc. Following an acknowledgement or acceptance procedure, the ECDIS automatically processes the update to the SENC.
2. **Semi-automatic Updating** is an updating method requiring human intervention to establish a link between the media used for transferring the update information and the ECDIS (e.g. inserting an updating diskette, or establishing a telephone communication link). Following an acknowledgement or acceptance procedure, the ECDIS automatically processes the update to the SENC.

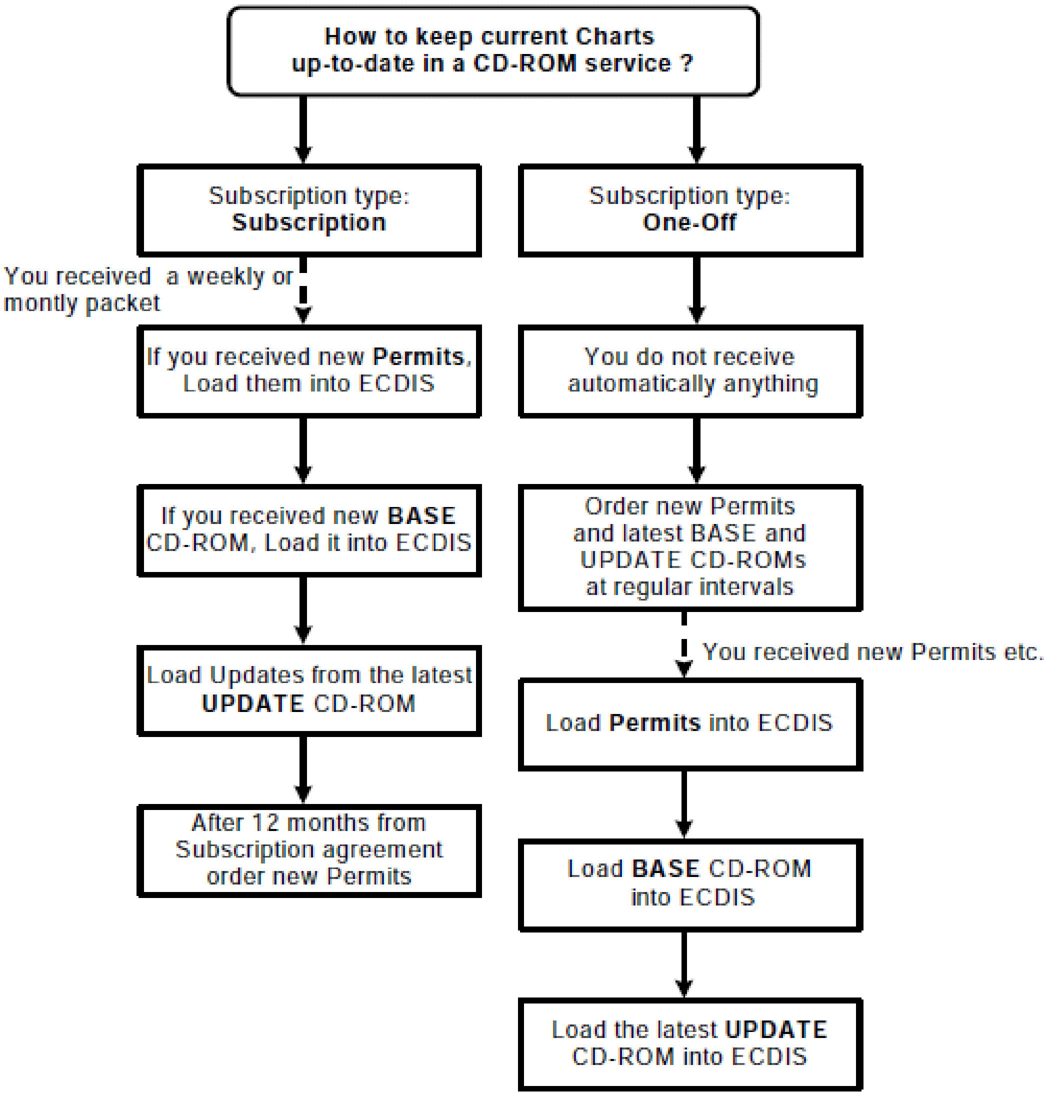
Distinction between these two sub-classes will be made only when it is considered relevant. In all other cases the term "Automatic Updating" covers either sub-class.

2. Data Base-Related Categories
   (a) **Integrated Updates** are those which alter (supersede) information contained in the previous SENC. The IMO PS calls for integrated updates as a minimum requirement.
   (b) **Non-integrated Updates** (e.g. manual) are those that do not alter the official ENC contents of the SENC. As such, this form of update simply adds additional information to the SENC. However, it can be acted on by ECDIS software in the same manner as is the data from the ENC. This form of updating, the capability for which is also a minimum requirement of the IMO PS, should be used only when Automatic Updating cannot be effected in a timely manner (e.g., for transient, preliminary updates such as radio navigational warnings affecting chart information or local notices issued by port authorities).

3. Aggregation Categories
Updates shall be aggregated in at least one of the following categories:
   (a) **Sequential Update**: The new correction information that is provided since the previous update set.
   (b) **Cumulative Update:** The collection of all sequential correction information which has been issued since the last new edition of the ENC or since the last official update applied to the SENC.
   (c) **Compilation Update:** The correction information which has been issued since the last new edition of the ENC or since the last official update applied to the SENC, compiled into a single, comprehensive ENC update. (Example: If a buoy has been relocated two or more times since the ENC Edition, only the last position, tailored to correct the position contained in the ENC Edition as issued, would be included. Thus, the application of a Compilation Update is to correct the effective ENC Edition at the time of its distribution to a user, which could be some months or years after the Editions initial distribution). Compilation update is implemented in S-57 by means of a re-issue of an ENC.

32.6.1: AUTOMATIC UPDATES

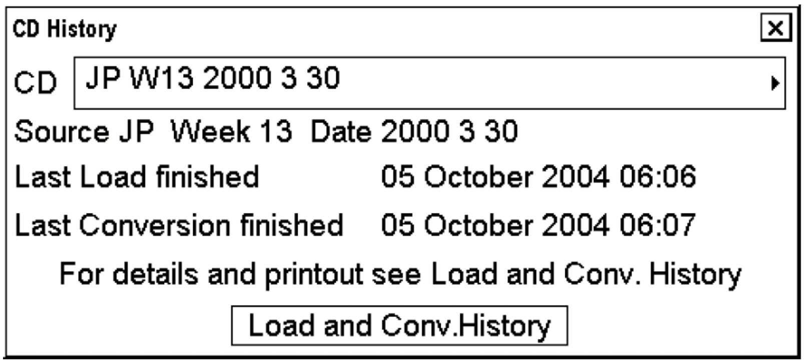
Keeping S57 charts up to date using an RENC



Base CD ROM from an RENC

A Base CD ROM from an RENC contains all the charts stored in an RENC when the CD ROM was issued. When you load charts (using the CD ROM catalogue) the following information is also loaded into the ECDIS hard disk:

- The Content Summary of the Base CD ROM
- Publisher Notes
- Product List



Update CD ROM from an RENC

Procedure for loading update CD ROM from an RENC to ECDIS is the same as the procedure for loading Base CD ROM

32.6.2: MANUAL UPDATES

SOLAS requires that mariners keep their charts up-to-date for an intended voyage. Mariners receive chart corrections and other essential information for the area of their intended voyage as

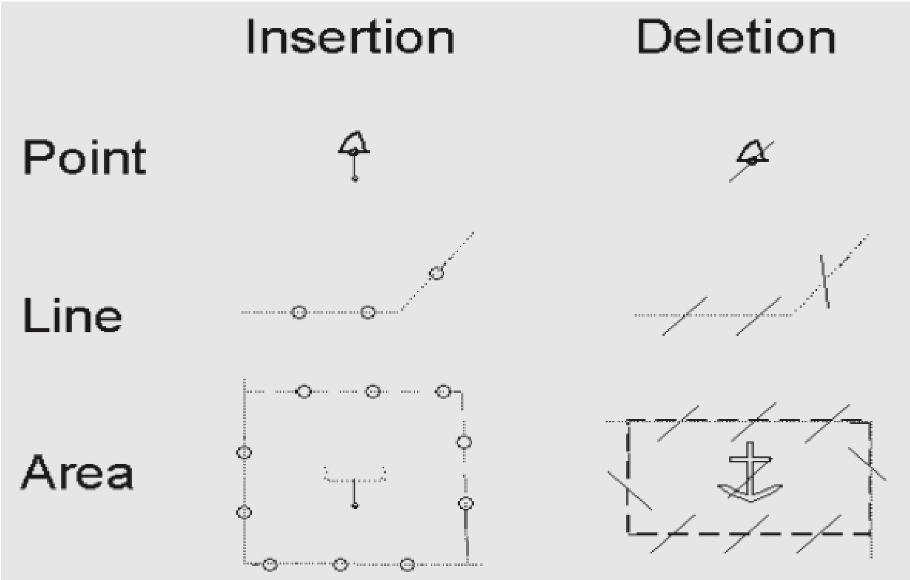
- Notices to Mariners (by post, by email, by fax, etc.)
- Navtex warnings

Mariners should also keep the electronic charts in their ECDIS up-to-date. Regardless of the chart material used, mariner must know which of these chart corrections are applied into their ECDIS charts and which of them needs to be added as manual updates.

Sometimes, manual correction is the only way to keep the chart data up-to-date since the commercial producers of the electronic charts usually lag considerably behind with chart updating services. Even where regular official updating services are available for ECDIS, it may be necessary to fall back on manual updating in case when the navigational warnings are transmitted by voice or printed notices. Manual updating offers the possibility of correcting all chart objects contained in an ENC by means of interactive chart editing functions. In practice however, the input of complex objects like e.g. land areas is time consuming and prone to errors. Most of the ECDIS manufacturers restrict the capability of manual correction to the objects which are directly relevant to the safety of navigation. These include fixed and floating aids to navigation, and the prohibited and restricted areas. The symbols used for the manually updated objects are identical with the standard chart symbols, they carry however special marking to distinguish them as manual corrections.

Manual update may include deleting an already existing object, modifying a position or other characteristics of an already existing object or inserting of a new object. In this ECDIS, manual updates are stored in a common database, which is used for both S57 and ARCS charts.

Mariners cannot permanently remove any of the official objects from the chart display. If a mariner needs to make obsolete any of the official objects he deletes them. Then, in practice, the deleted features are still visible, but they are displayed a certain way to indicate a deleted object.



However, a mariner can remove objects that he has inserted himself.

Note that the manual updates have no automatic connection to any automatic update received later for S57 or ARCS charts. If a manual update itself became obsolete, because the official chart has been updated to include the update defined as a manual update, the mariner must himself delete the obsolete manual update in question.

This ECDIS records complete usage of manual updates. All deletions, modifications and insertions are recorded and time stamped. If the mariner wishes to see what kind of manual updates he had in the past, for example, two weeks ago, he uses Update History to specify the relevant date range.

Last but not least, the user is supported with functions that imitate the traditional manner of chart corrections. Simple lines and areas filled with transparent colors can be placed electronically as well as commenting text strings on top of the displayed chart. Like pencil notes on a paper charts can be erased, this manual notes can be removed later from the electronic chart by special functions.

- **Symbols to Use With Manual Updates**

Manual updates can be used for the following purposes:
• Keep charts up-to-date using similar symbols as the real chart uses. We refer to these symbols as "True symbols".

• Keep charts up-to-date using conspicuous orange symbols reserved for this purpose. We refer to these symbols as "Orange symbols".
• Add additional mariner information using conspicuous orange symbols reserved for this purpose.

Orange symbols are recommended because then you, your mates and pilots can easily find these symbols. Another benefit of the orange symbols is that they are very easy to insert. However, orange symbols do not cover all possibilities. Experienced operators can use true symbols to create their own cartography.

- **Manual Update Planning With Orange Symbols**

The manual update editor operates in sessions. You create a session when you activate the Manual Update Planning dialog box, displayed by choosing Manual Update from the Chart menu followed by Planning from the sub menu. You can freely delete, modify, copy or create chart objects until you feel finished with your session. Then, you terminate your session by clicking the **Accept Manual Updates as Permanent** button then the ECDIS stores your manual updates permanently. If you need to leave your manual update session and discard all modifications made during the current session, click X in upper right corner.

Note: The manual update editor is only available in the North Up or Course Up orientation mode.

New, Copy, Modify, Delete: These buttons are used to collect chart objects into a list shown in the Manual Update Planning dialog box for further editing during current session of manual update planning. **New** creates an object from scratch. **Copy** creates an object using an existing object as an example. **Modify** changes an existing object. **Delete** removes an existing object.
Remove from List: If you made a manual update by mistake, you can remove it if you haven't accepted it yet as permanent. You can remove it by choosing (highlighting) that chart object in the List then clicking the **Remove from List** button.
Edit Properties: You can edit properties of a selected (highlighted) chart object by using the **Edit Properties** button.

Inserting New Orange Symbols
The mariner can insert a new object either using New or Copy in the Manual Update Planning dialog box. With New he creates a new feature from scratch. With Copy he uses an already existing object as an example for the newly inserted feature.

Inserting New Orange Symbols Using "*NEW*"
When you want to create a new object from scratch, you start creating by clicking the New button in the Manual Update Planning dialog box. A New Object window appears. Use the default Category Standard Orange to insert a new orange symbol.

Inserting New Orange Symbols Using "*COPY*"

You can make new orange symbols by copying existing orange symbols. Then you pick up an orange symbol and make a copy of it.

Deleting Orange Symbols

The mariner cannot permanently remove any of the official chart objects from the chart display. If the mariner needs to remove any of the official chart objects, he is allowed to mark them as deleted. In practice the deleted chart object is still visible, but it has a special presentation for a deleted object on top of it.

Editing Position of Orange Symbols

An object can be type of point, line or area.
• Point has only one point in its presentation.
• Line can consist of one or more chains. A chain consists of two or more points.
• Area consists of a line that is closed.

Manual Update Planning With True Symbols

Same as with Manual Update Planning with Orange Symbols

Deleting Chart Objects

The mariner cannot permanently remove any of the official chart objects from the chart display. If mariner needs to remove any of the official chart objects he is allowed to mark them as deleted. In practice the deleted chart object is still visible, but it has a special presentation for a deleted object on top of it.

Note: If you deleted an official ENC chart object, a deletion mark is added over the original chart object that is still visible. If you delete a manual update chart object, then it is removed from the chart display based on date of deletion.

Modifying Chart Objects

The mariner cannot permanently remove from the chart display any of the official chart objects, but he can modify position and/or properties of chart objects. When the mariner modifies a chart object, the ECDIS will mark original chart object as deleted and a copy of original chart object as inserted.

CH. 33: SYSTEM RESET & BACKUP

No electronic system is completely failsafe. IMO Performance Standards therefore require that the “overall system” include both a primary ECDIS and an adequate independent back up arrangement.

The purpose of an ECDIS back-up system is to ensure that safe navigation is not compromised in the event of ECDIS failure. This should include a timely transfer to the back-up system during critical navigation situations. The back-up system shall allow the vessel to be navigated safely until the completion of the voyage.

Such arrangements shall include:

1. Facilities enabling a safe take-over of the ECDIS functions in order to ensure that an ECDIS failure does not result in a critical situation;
2. A means to provide for safe navigation for the remaining part of the voyage in case of ECDIS failure.

Back-up system should be capable of performing the following functions:

1. ***Chart Information***
   System should display in graphical (chart) from the relevant information of the hydrographic and geographic environment which are necessary for safe navigation.
2. ***Route Planning***
   Route planning and safely taking over of the route plan originally performed on the ECDIS.

3. ***Route Monitoring***
   The back-up system should enable a take-over of the route monitoring originally performed by the ECDIS, and provide at least the following functions:
   a. Plotting own ship's position automatically, or manually on a chart;
   b. Taking courses, distances and bearings from the chart;
   c. Displaying the planned route;
   d. Displaying time labels along ship's track;
   e. Plotting an adequate number of points, bearing lines, range markers, etc. on the chart.
4. ***Voyage Recording***
   It should be able to keep a record of the ship's actual track, including positions and corresponding times.

Hence, a back-up system can comprise of:

1. A second fully compliant ECDIS independent of main ECDIS with separate main and emergency power source and independent positioning fixing system;
2. An up-to-date paper chart folio;
3. An ECS providing the display of chart presentation using ECDIS software and charts and ECS;
4. Many administrations have accepted the ECDIS operating in Raster Chart Display System (RCDS) mode when complying with IMO requirements. E.g. AMSA requires paper charts when operating in beyond coastal water when operating in RCDS mode along with risk assessment need to be presented for area within near coastal waters to dispense with the need for carrying paper charts.

And the consequences to data storage while ECDIS PC is down are:

- Despite continuous functioning of sensors, the consequence while ECDIS PC is down is that all data storage ceases.
- There will be a gap graphically on the display upon restoration of ECDIS PC and a corresponding gap in electronic logbook data.

What is an adequate backup system?

This question sums up most of the different interpretations of SOLAS from nation to nation. Since failure of the primary ECDIS navigation system is a very real and appropriate concern, authorities responsible for safe commercial navigation have put extra care and attention into their answers of the question “what then?”

Some countries regard only a fully-updated folio of approved paper charts as adequate back-up. Others permit ships to employ a second ENC-fuelled ECDIS to be used as a back-up, as long as it has an independent power supply. Still others allow a second ECDIS, with an independent power supply, which uses RNCs, or raster nautical charts. Some flag states may allow a non-ECDIS electronic chart system (called an ECS) that uses ENC data as back-up, provided it meets IMO back-up rules. Finally, some flag states may permit the use of chart radar as back-up.

As practically every country takes a unique stance in respect to this question, the only definitive answer is to speak to your flag state authority for specific guidance. The expansion of ENC coverage, increased usage of ECDIS and commercial aspects of navigation technology will all play a role in determining how these guidelines change.

In instances where several back-up arrangements are possible, each operator must weigh the relative advantages of different systems based on their existing systems, lifetime costing of new arrangements, training and safety and operational considerations.

33.1: BACKUP TO AN ECDIS SYSTEM

The role of back up to an ECDIS system is defined very clearly by the IMO in MSC resolution 232 (82). It is not a requirement that two independent ECDIS stems are fitted. This would mean that route planning for instance would have to be done on both systems if they were independent. However, IMO makes it clear that the back up system should take over the route plan originally performed on the ECDIS for example. Route planning, presentation of chart information, route monitoring, updating etc is carried out on the main ECDIS and it is correct that a data link provides that this information should be passed continuously to the back up device such that in the case of a failure of the main ECDIS system the back up system is reasonably up to date with the route etc.

This is how it is meant to be. Those who fit two ECDIS systems without the data interconnection would have to route plan twice and route monitor twice etc - not the intention. In summary the back up device does not need to be a complete ECDIS just a subset that will meet some minimum requirements if the main ECDIS fails. Appendix 6 of the Resolution sets out the back up requirements.

It's a sad fact that many existing mariners are going to be presented with a layered ENC display which is confusing if you have not been trained and it is recommended that anyone who has not been on a training course for ECDIS should do so. The recent grounding of the CFL Performer is a good example of lack of training and it is quite clear from the formal safety assessment carried out by the Norwegians that is safer to use an ECDIS than paper.
The danger of Viruses must also be considered. Hopefully, your ECDIS systems are not connected to the internet or other virus generating receiving equipment. The only thing that should be put into an ECDIS is an approved encrypted CD from a reputable agent.

Reference: (***www.impahq.org***)

33.2: Transfer to Back-up

The back-up system must ensure that safe navigation is not compromised in the event of ECDIS failure. In particular, a timely transfer to the back-up must be possible during critical navigation situations. At least in coastal waters and harbor approaches this means that the back-up system has to be available virtually instantaneously, with little additional effort by the OOW. In particular, the back-up needs to have the planned route displayed on an appropriate and up-to-date chart available for rapid use. Other critical data that may be stored within the ECDIS, such as Maritime Safety Information and pilotage information, also needs to be appropriately available for use with the back-up system. It is emphasized that an electronic back-up system should have been set to ensure that all user options as far as possible match the options set on the primary system. In particular, this should include own ship dimensions; safety contours and depths; and safety domain settings.

Once safe navigation is restored using the back-up, ideally with the help of a summoned officer, steps should be taken to get the primary system back to working status. In general, this should not be the task of the OOW and should be left to other appropriate Bridge staff.

1. **Back-up Using Dual ECDIS**
   When equipment fails on a dual ECDIS system, it is normally just a matter of moving across to the second equipment and ensuring that it is in route-monitoring mode with own ship initially displayed on the largest scale chart available and that the appropriate route has been selected. This safe and easy change greatly recommends the use of such a back-up option but it underlines the need for both ECDIS to be preloaded with the planned and alternative route data and that the charts are kept up-to-date. A modern Integrated Navigation System using multiple MFTSs (Multi Function Task Station), effectively acts as at least a dual ECDIS configuration.

Both units in a dual system should be kept switched on in normal circumstances. As well as allowing easy transfer in the case of a failure, it has the everyday benefit of allowing two operators to have independent use. This, for example, could permit planning activities for a future voyage to be carried out by a member of the bridge staff not currently on watch, without compromising the display being used by the OOW. Obviously, it also allows two on-watch bridge officers to have independent access to the charted position. However, in general it would be appropriate for one ECDIS to be assigned as the primary system and normally used by the navigator. This would mean, for instance, that any electronic notes and other manually input information into the ECDIS would always be easily accessible. Some dual configurations may automatically update both ECDIS units, when such additional data is added, and in this case it may not be so important to assign primary and back-up stats.

2. Back-up Using Other Electronic Systems

The main contenders for electronic back-up, other than a dual ECDIS solution, are the use of an approved ECS capable of displaying ENC data or a *chart radar* specifically approved for ECDIS back-up. Although it is appropriate for all back-up solutions, the availability of a flag state-issued Certificate of Compliance will be useful to indicate to port state inspectors that the back-up solution meets the requirements of the flag state.

If a chart radar is being used the screen should be optimized to enable its best use for chart work. This will almost certainly require information to be displayed that generally meets that contained in the ECDIS Standard Display. Radar work should therefore be mainly transferred to the other radar display(s), as the screen is likely to be over-cluttered for effective radar use.

An ECS back-up should also be set to show the information normally available on the ECDIS Standard Display. The user should be careful to ensure that ENCs are being displayed, rather than private data. For either back-up solution, it is important that the chart data is up-to-date and that the relevant planned route is available. Care should be taken to ensure that parameters regarding own ship, including safety contours and depths are correctly set. Since these back-up solutions do not meet ECDIS requirements, extra caution must be used in navigating the vessel because some information and facilities available on a true ECDIS may not be available.

3. Back-up Using Paper Charts

If paper charts are to be used as a back-up, an appropriate paper chart for the ship's current position must be available on the chart table, corrected with the latest Notices to Mariners, and with current position having been plotted on it at suitable intervals. It is essential that planned primary and alternative routes have been plotted as part of the planning process. The IHO maintains a list of charts that coastal states see as appropriate when using paper charts as a back-up to ENCs. The list also includes the paper charts needed when using RCDS mode. The list can be accessed on the IHO website in the ENC/RNC Coverage Catalogue section.

In the event of an ECDIS failure, own ship's position and time should immediately be plotted on the back-up paper chart, using the displayed data on the primary electronic-fix system. If this system has also failed, steps should be taken to plot a manual fix. If immediate visual and radar fixes are unavailable, for instance on an ocean leg, the OOW's best estimate of position should be plotted on the chart, ideally from calculating an EP from previous position and time plots made on the back-up paper chart, from an EP from the last log entry or, if there is no recent formal record, from the immediate memory of the last ECDIS observed position.

Emergency Charts

If the official back-up system is electronic, it is recommended by The Nautical Institute that consideration is given to carrying a voyage-appropriate set of mainly small scale paper charts. These can then be used as an emergency back-up, in case of failure of both the primary and the electronic back-up system. This advice may be amended in the light of experience but is considered prudent.

The charts should be selected to allow the vessel to proceed to an area of safety if both the ECDIS and its back-up should fail, where pilot or other assistance would be available. It is recommended that these are referred to as 'emergency paper charts'. These charts would only need to be made available on the chart table for possible use after the primary system had failed and only subsequently used for navigation if the electronic back-up also failed. They would have to be used with great care since they would not necessarily be up-to-date or to a scale that would normally be used when navigating with paper charts. If they have to be used in an emergency, coastal authorities and/or the flag state should be informed so that advice can be sought. In addition, it may be possible for the ship to receive faxed or scanned copies of critical large scale charts.

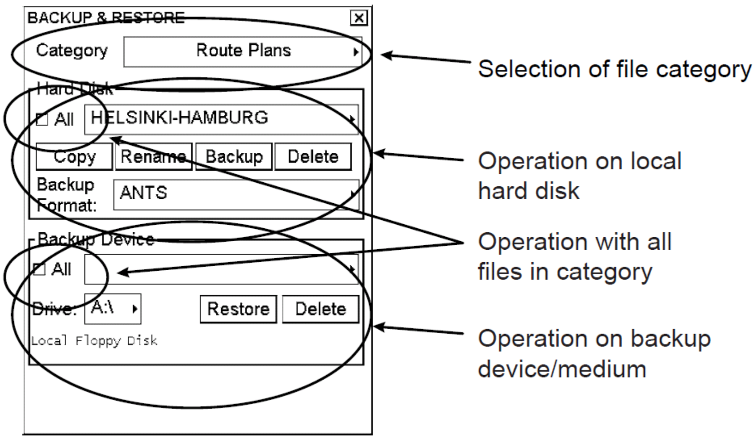
It is emphasized that the main use of the emergency charts would be to navigate to a suitable position where assistance can be made available. They should not be considered to be 'get-you-home' charts. It is possible that in the future, hydrographic offices will provide suitable dedicated folios for emergency paper charts.

An alternative that could also be considered would be to carry a laptop computer with suitable chart software. This would need to be loaded with chart data, which could perhaps be from a reputable supplier of private data, and appropriately covered the entire voyage. Consideration should be given to the powering of the laptop computer should a fault occur in the ship's main power supply. Positional data could either be fed in manually or via an emergency hand-held position-fix system, such as using a GNSS-enabled mobile phone. These normally allow a wireless connection to an appropriate laptop computer. The chart system on the laptop should only be used if both the statutory primary and secondary systems have failed and only to get the vessel to a suitable location where a pilot or other assistance can be made available. Coastal authorities and the flag state should be informed when forced to navigate by such an emergency system.

CH. 34: ARCHIVING WITH ECDIS DATA MANAGEMENT UTILITY

34.1: Backup Operations (Example only:FEA-2107 / FEA-2107-BB / FEA-2807)

There are several menus from which the operator may initiate backup and restore functions. From those menus the operator may execute hard disk operations such as backup, copy, rename and delete. The operator may make backup copies to backup devices or restore from backup device to hard disk. These pushbuttons and menu commands, which are used to access the system's database, are listed below.
Note: Use only IBM PC formatted floppy disks.
The Backup & Restore dialog box is where backup and restore operations are initiated.



Choosing Appropriate File Category

The system automatically selects corresponding file depending on your selection. The categories consist of the following files:
• Route plans
• User Charts
• Pilot Data
• Installation parameters
• Chart Display Settings
• Paper Chart Setups
• Presentation Libraries
• Logs
• Manual Updates
• All Charts and Updates
You can select desired category from the File category box in the Backup & Restore dialog box. For the selected category, the system shows all the possible functions executable with the selected category.

Copying a File

You can make a copy of an original file using the Copy function in the Backup & Restore dialog box.

Renaming a File
You can rename a file using the Rename function in the Backup & Restore dialog box.

Backing up a File to a Floppy Disk
You can make a backup from an original file to a floppy disk.

Restoring a File from a Floppy Disk
You can restore a file with one stored on a floppy disk.

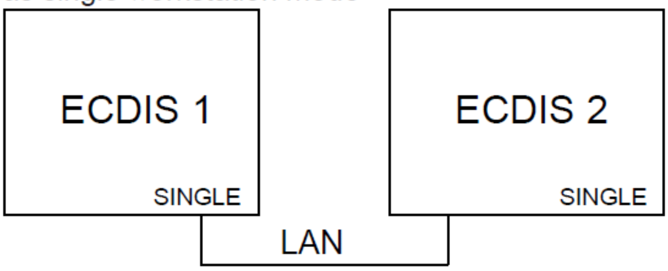
Deleting a File
You can delete a file.

34.2: Moving a File to Planning or Navigation Station (Example on FEA-2107 / FEA-2107-BB / FEA-2807)

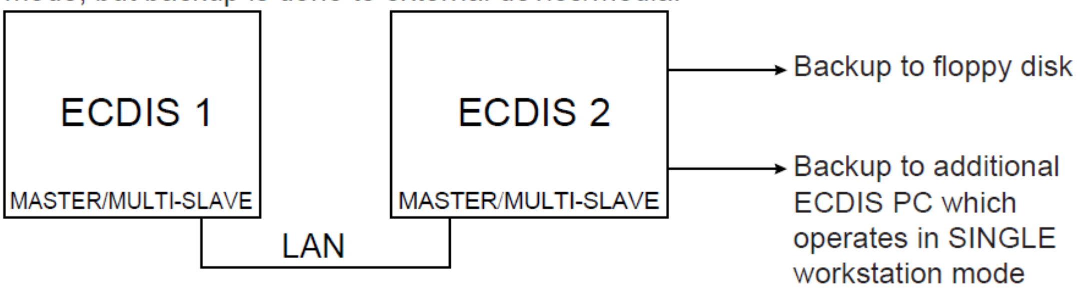
If there are two ECDIS workstations connected via a LAN, files can be moved from one workstation to another and vice versa.

Note: The intention of the Backup function is to make a backup copy of a route, user chart, etc. to a backup medium. If you want to copy charts, routes, user charts, etc. between ECDIS workstations, it is recommended that you use the Restore function instead of Backup. For use of Backup, see the illustration below for when it is possible to use the Backup function.

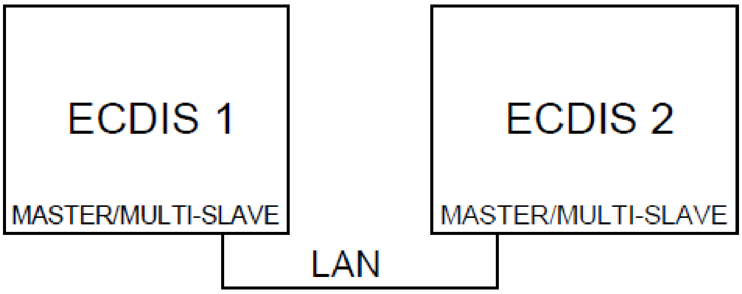
Between ECDIS workstations when both worstations are set as single workstation mode



Between both workstations are set as Master/Slave or Multi-workstation mode, but backup is done to external device/media.



NOTE: DO NOT use the backup function between two ECDIS workstations when both workstations operate as master/slave or multi-mode (or one workstation mode indication is red (single))



Reading a File from Planning or Navigation Station
If there are two ECDIS workstations connected via a LAN, it is possible to read files from planning station to navigation station and vice versa.

Loading User Chart and Route Files of Former Vector System Format
Route and user chart files can be read in vector system format (Inc) files. When loading Inc format files, the ECDIS converts the files to the format used with the ECDIS.

Saving User Chart and Route Files in Former Vector System Format
The Route and User chart files can be read in vector system format (Inc). When moving files from the ECDIS to a backup device the ECDIS converts the file to Inc format.

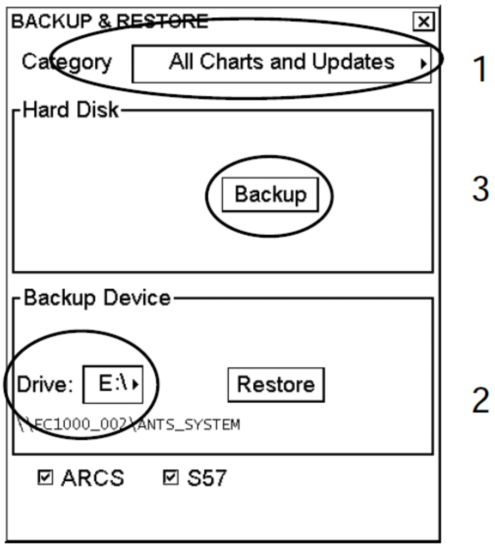
Saving a Route as an ASCII Text File
Sometimes it is useful to save route information as an ASCII text file for use with some other application, or to restore some ASCII text produced by some other application to the ECDIS.

The following formats are available for route backup and restore:
- ASCII PROPRIETARY
- ASCII POSITION (list of Latitude/Longitude values)
- ASCII WPT NAME POSITION (list of WPT names and Latitude/Longitude)
- ASCII POSITION WPT NAME (list of Latitude/Longitude and WPT names)
- ASCII FULL (all route related information)

Restoring a Route from an ASCII Text File
Sometimes it is useful to restore to the ECDIS route information stored in an ASCII text file that was produced by some other application.
The following formats are available for route backup and restore:
- ASCII PROPRIETARY
- ASCII POSITION, list of Latitude/Longitude values
- ASCII WPT NAME POSITION, list of WPT names and Latitude/Longitude
- ASCII POSITION WPT NAME list of Latitude/Longitude and WPT names

- ASCII FULL, all route related information

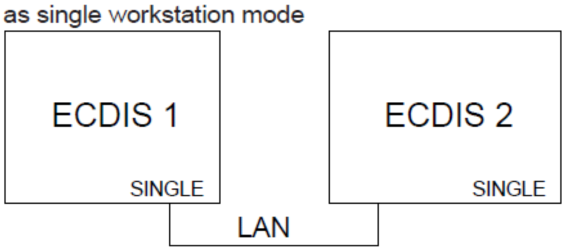
Backing up Chart Material
The ECDIS lets you keep a chart database identical both in the hard disk of the ECDIS and the hard disk of the backup ECDIS.



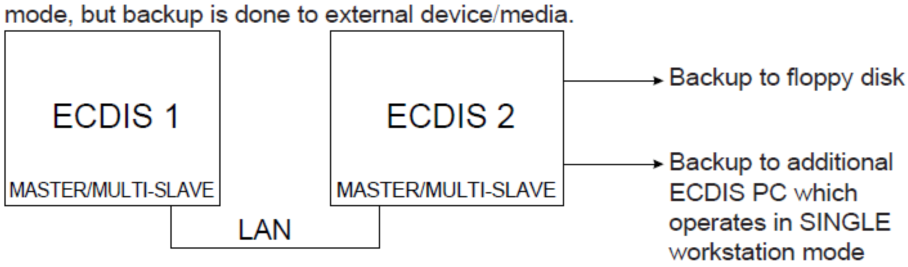
Note: To copy charts between ECDIS workstations, it is recommended that you use the Restore function instead of Backup. For use of Backup, see the illustration below for when it is possible to use the Backup function.

After the backup has been completed, the hard disk content of the backup ECDIS is identical with backup ECDIS. However, the backup ECDIS doesn't automatically start to use possible new material.

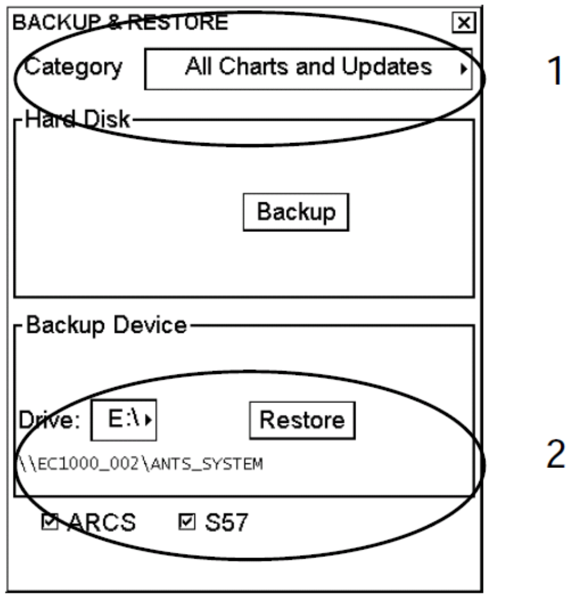
Between ECDIS workstations when both worstations are set as single workstation mode



Between both workstations are set as Master/Slave or Multi-workstation mode, but backup is done to external device/media.



Restoring Chart Material
The ECDIS lets you keep a chart database identical both in the hard disk of the ECDIS and the hard disk of backup the ECDIS.



Note: After the restore has been completed, the hard disk content of the backup ECDIS is identical with backup ECDIS. However, the backup ECDIS doesn't automatically start to use possible new material.

CH. 35: DATA LOGGING, LOGBOOK AND PLAYBACK

Using ECDIS, a record of the voyage is required as it is for paper charts. The voyage record must be suitable to reconstruct the voyage and may be used both for an accident investigation and, e.g. by the ship owner or the master, for future voyages on the same route. As a minimum the following information is recorded:

- Short term record
  For 12 hours at interval of no more than 1 minute
  - time, position, course and speed of the ship to enable the precise reconstruction of the immediate past history of the ship's motion, and
  - source, edition number, date, cell and update version of the ENCs in use to ascertain which charts were actually displayed;
- Long term record
  For the entire voyage at intervals of no more than 4 hours
  - the past movements of the ship to enable the coarse reconstruction of the entire voyage.

The 'entire voyage' is defined as a maximum period of three months and it can therefore be expected that a track record is kept for all voyages at least for a three month period. Once stored, the system must safeguard the integrity of the stored information and prevent any subsequent manipulation of the data.

A typical recording can be inspected on the screen as shown below, Fig. 35.1 ('Past track list'). For the primary sensor DGPS for a period of 12 hours at one minute intervals, the values of date, UTC, latitude, longitude, heading, speed, and position offset (if any; here Zero) are recorded. For every minute of time (UTC = 11:00 is highlighted), the 'Details' of the loaded charts and the applied updates can be viewed. This is to check which charts ('Were usage or scale appropriate?') the Mariner had actually displayed on the screen, not only available in the SENC. And this voyage record cannot be modified.

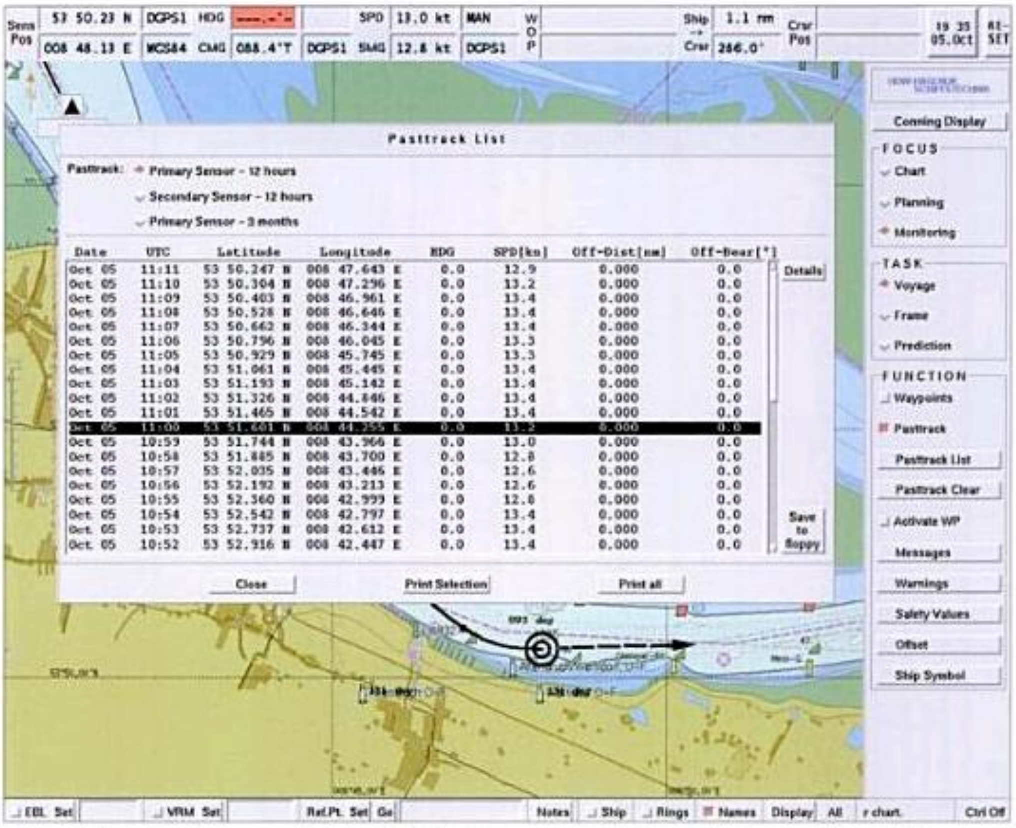


Fig. 35.1: Voyage recording by ECDIS. The voyage (in 1 minute intervals) and the use of charts/updates can be reconstructed. Sea area: Elbe approach. Source: HDW-Hagenuk.

35.1: ECDIS Logs

Inbuilt logbook function of ECDIS may be used to save voyage records. All items available for logging provided by maker may also be selected for saving the entire logs. Electronic files for these voyage records may be maintained for a certain period of time and can be archived as per the company's requirement. (One year for NYKSM and the name of the file should be in the format YYYYMM-VSL – Voyage No. and should not be edited after initial save).

ECDIS log may be used for the future reference for vessel track history and inspection of system functions, alarm setting and user's responses

ECDIS also records various voyage-related items like movement and position of own ship and dangerous radar targets (from ARPA radar). These items are recorded in the following logs:

Voyage log:	Records entire voyage, i.e., a sailing of a route from first point to the last.
Details log:	Records position, speed and course once every minute.
Danger Targets log:	Records tracked target data.
Chart Usage log:	Records information of used charts in display.

Alert log: Records alerts generated by the system.

The operator may print the contents of any log.

1. Voyage Log
ECDIS has the capability of recording and be able to reproduce certain minimum elements required to reconstruct the navigation and verify the official database used during the previous 12 hours.

The following data shall be recorded at one minute intervals:
1. To ensure a record of own ship’s past track: time, position, heading and speed; and
2. To ensure a record of official data used: ENC source, edition, date, cell and update history

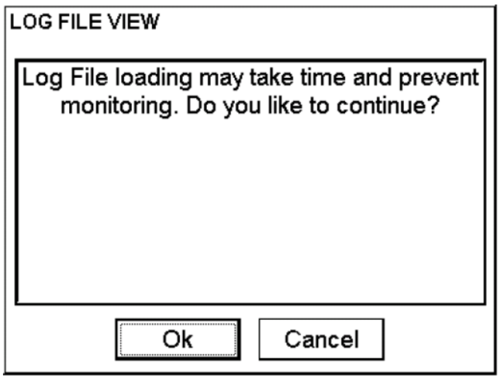
In addition, ECDIS also has the capability to record the complete track for the entire voyage, with time marks at intervals not exceeding 4 hours.

ECDIS store and be able to reproduce certain minimum elements required to reconstruct the navigation and verify the official database used during the previous 12h.

- The following data should be recorded at one-minute intervals:
  1. To ensure a record of own ship's past track: time, position, heading, and speed; and
  2. To ensure a record of official data used: ENC source, edition, date, cell and update history.
- In addition, ECDIS should record the complete track for the entire voyage, with time marks at intervals not exceeding 4 h.
- It should not be possible to manipulate or change the recorded information.
- ECDIS should have the capability to preserve the record of the previous 12h and of the voyage track.

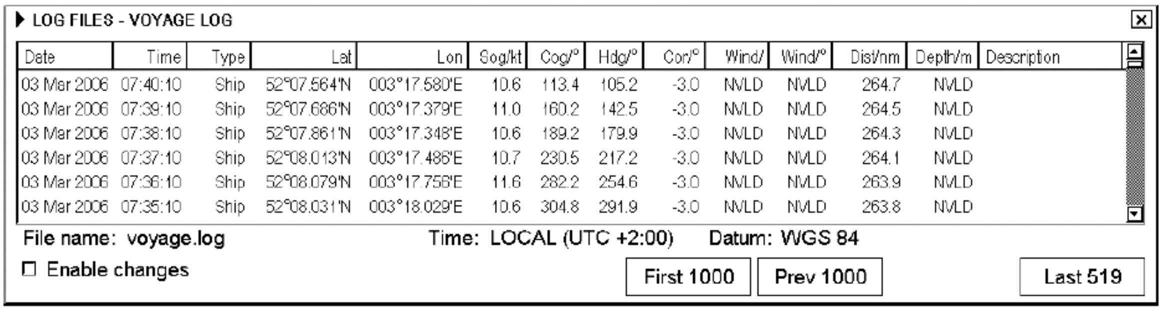
The voyage log holds data for the entire voyage, recording the following data:
- Changes of course and speed. User can define limits for course change and speed change of your ship to be recorded. This data is filed in the log as type "Ship".
- User is able to define time period, how often there is a recording regardless of course or speed changes. (For example, once per 4 hours). This data is filed in the log as type "Auto".
- Man Over Board event. This data is filed in the log as type "MOB".
- Standard event. This data is filed in the log as type "User".
- Alerts generated by the system. User is able to select alerts, which are recorded into the Voyage log. This data is filed in the log as type "Alert".
- Positions. This data is filed in the log as type "Posdev".

Viewing the voyage log



The system will start viewing program of log.

You may print the entire log or a desired part.



Date	Time	Type	Lat	Lon	Sog/kt	Cog/°	Hdg/°	Corr/°	Wind/	Wind/°	Dist/nm	Depth/m	Description
03 Mar 2006	07:40:10	Ship	52°07.564'N	003°17.580'E	10.6	113.4	105.2	-3.0	NVLD	NVLD	264.7	NVLD	
03 Mar 2006	07:39:10	Ship	52°07.686'N	003°17.379'E	11.0	160.2	142.5	-3.0	NVLD	NVLD	264.5	NVLD	
03 Mar 2006	07:38:10	Ship	52°07.861'N	003°17.348'E	10.6	189.2	179.9	-3.0	NVLD	NVLD	264.3	NVLD	
03 Mar 2006	07:37:10	Ship	52°08.013'N	003°17.486'E	10.7	230.5	217.2	-3.0	NVLD	NVLD	264.1	NVLD	
03 Mar 2006	07:36:10	Ship	52°08.079'N	003°17.756'E	11.6	282.2	254.6	-3.0	NVLD	NVLD	263.9	NVLD	
03 Mar 2006	07:35:10	Ship	52°08.031'N	003°18.029'E	10.6	304.8	291.9	-3.0	NVLD	NVLD	263.8	NVLD	

Note 1: You can add a description to a log entry. Check Enable changes then enter description desired in the text box, using the scrollwheel.

2. Details Log

The details log contains voyage information of the last 12 hours. Various information is recorded in the details log once per minute.

- Date and time
- Position of your ship as output by selected navigator.
- Alignment (range, bearing) values, if used.
- Speed over ground and course over ground.
- Heading.
- Gyro correction value, if used.

Viewing the Details Log

LOG FILES - DETAILS LOG

Date	Time	Type	Lat	Lon	Align/nm	Align/°	Sog/kt	Cog/°	Hdg/°	Corr./°
03 Mar 2006	07:43:10	Auto	52°07.779'N	003°18.222'E	0.0	0.0	10.6	2.1	353.2	-3.0
03 Mar 2006	07:42:10	Auto	52°07.618'N	003°18.106'E	0.0	0.0	11.1	48.7	30.5	-3.0
03 Mar 2006	07:41:10	Auto	52°07.535'N	003°17.861'E	0.0	0.0	10.5	75.7	67.9	-3.0
03 Mar 2006	07:40:10	Auto	52°07.564'N	003°17.580'E	0.0	0.0	10.6	113.4	105.2	-3.0
03 Mar 2006	07:39:10	Auto	52°07.686'N	003°17.379'E	0.0	0.0	11.0	160.2	142.5	-3.0
03 Mar 2006	07:38:10	Auto	52°07.861'N	003°17.348'E	0.0	0.0	10.6	189.2	179.9	-3.0

File name: details.log Time: LOCAL (UTC +2:00) Datum: WGS 84

First 1000 Prev 1000 Last 445

3. Danger Targets Log

The danger targets log stores information about targets which are received from an ARPA Radar (ARPA Targets) and/or targets which are received from an AIS transponder (AIS targets).

If a ARPA target or AIS target is within the set CPA and TCPA, information of all tracked targets (including non-dangerous targets) are recorded into the danger targets log. This data is as follows:

- Date and time, index of target (number of tracked target on radar or IMO MMSI number from AIS transponder).
- CPA and TCPA of both AIS and tracked targets
- Position (Lat, Lon), speed (Spd) and course (Crs) of both AIS and tracked targets.
- Heading (Hdg) information of AIS target.

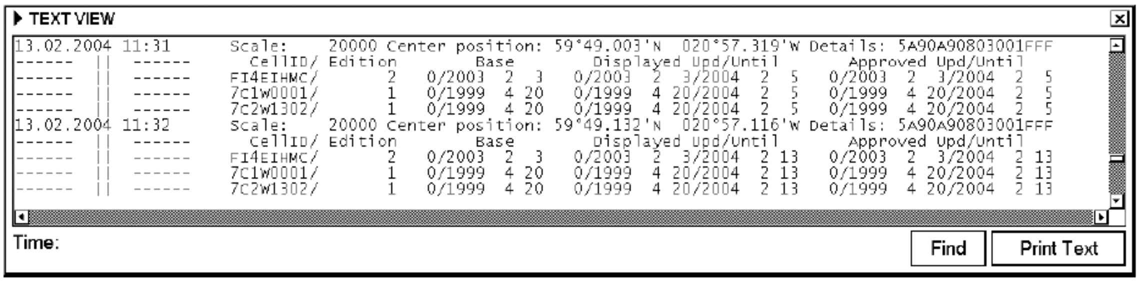
Viewing the Danger Target Log

4. Chart Usage Log

The chart usage log stores which charts were displayed on the ECDIS chart display area or which were used for chart alarms. The following information is recorded in the chart usage log:

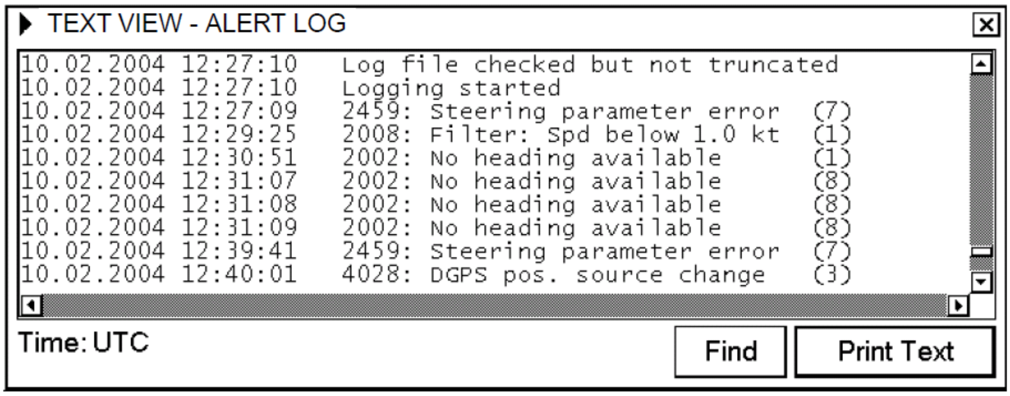
- Chart ID
- Chart edition
- The latest update included to chart
- Displayed Updates Until
- Approved Updates Until
- Center position of display (Lat, Lon).
- Scale of chart display

- Details of chart selected for display

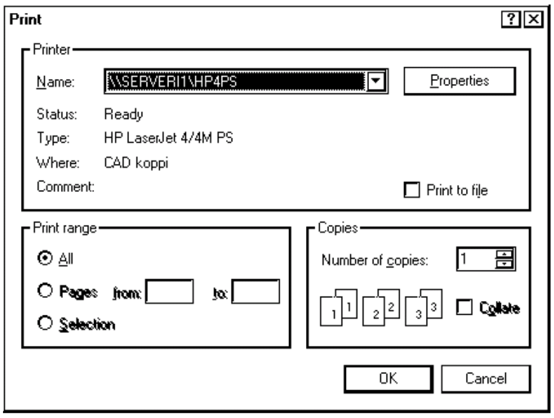


5. Alarm Log

The Alarm Log collects and records alarms generated by the system.



Printing Latest Alarm



35.2: Events and Man Overboard Functions

The Events and Man Overboard (MOB) functions are accessed with the mouse.

- **(Event):** Records an event to the logbook. You can also write a comment (up to 48 alphanumeric characters) for this event. The comment is displayed only in the electronic chart area if Events is selected for display in the Tracking page of the Chart Display dialog box.
- **(MOB):** Records MOB position to the logbook. Position of this event is also displayed on the chart as a red mark.

35.3: PLAYBACK FUNCTIONS

The passage recording playback function is in compliance with IEC 61174 requirements regarding 12 hour log and is used for viewing all the details of the past voyage by using the data automatically archived by the system in the process of its operation.

All system information and vessel movements saved in the internal database may be used by the system's playback function.
The following voyage playback options are available:

- To be able to reconstruct past passage for review, investigating route plan
- To review of system functions, including the past alarms, dangerous targets.

LESSON 5: ECDIS RESPONSIBILITY

CH. 36: RESPONSIBILITY

With increasing automation and reliability of ship's navigation systems, it is easy to place undue reliance upon them. In particular, positioning, even when just GPS is used, is rarely noticeably inaccurate and seemingly always available. An individual may not experience or notice any problems, even over extended periods and therefore may become complacent. However, real problems do occur and every year a number of these lead to serious incidents for unwary navigators.

A good OOW is continually seeking either to confirm or deny the integrity of the navigation system and solution. Importantly, checking of positional integrity also help keep the OOW properly aware of the current navigational situation. Then, if the electronic equipment failure occurs, either totally or by giving false readings, the navigator will recognize early, and more safely manage, the abnormal circumstance.

It is therefore important that the immediate planned route and its potential dangers always remain fully in mind so that quick decisions can be made if the system fails. Of course, these decisions require much more information than is directly obtainable from ECDIS.

36.1: COLREGS

Rule 5 – Lookout
Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by ***all available means*** appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 7 – Risk of Collision
(a) Every vessel shall use ***all available means*** appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.

36.2: SOLAS

The International Convention for the Safety of Life-at-Sea (SOLAS), 1974 was adopted by IMO at the International Conference on the Safety of Life at Sea on 1 November 1974. SOLAS entered into force on 25 May 1980 and its 1978 Protocol on 1 May 1981. SOLAS has been ratified by all the major maritime nations and applies to all ships on all voyages, except ships-of-war and vessels solely navigating in the Great Lakes and St. Lawrence Seaway of North America.

When first adopted, SOLAS applied to all sea-going ships of 500 gross tons or more. Chapter V dealt with navigation safety-related issued, including danger and distress messages, shipborne navigational equipment, and nautical publications. SOLAS Chapter V requires, amongst other matters, that ships of 1,600 gross tonnage and upwards be outfitted with a Gyro-compass and radio-navigation equipment – both essential components of ECDIS. The use of electronic chart is not mentioned in the SOLAS text adopted in 1974 but its anchoring point is Regulation 20 (Nautical Publications) of Chapter V. This regulation states:

All ships shall carry adequate and up-to-date charts, sailing directions, lists of lights, notices to Mariners, tide tables and all other nautical publications necessary for the intended voyage.

In 1994, IMO began work on revising Chapter V of SOLAS. Revision was considered necessary as a result of new technologies and performance standards that IMO had adopted to improve navigation safety. The new version of Chapter V went into effect on 1 July 2002, and applies to all ships on all voyages unless specifically exempted. Exempted vessels include warships, government-owned or operated ships that are not used for commercial service, and vessels navigating solely in the Great Lakes of North America. However, the revised SOLAS Chapter V does allow Maritime Safety Administrations to decide what extent many of the requirements should apply to some vessels:

1. Fishing vessels;
2. Ships operating in national waters;
3. Ships below 150 gross tonnage;
4. Ship below 500 gross tonnage and not engaged in international voyages.

The new SOLAS Chapter V has four regulations that directly pertain to ECDIS: 2, 18, 19, and 27.

Regulation 2.2: Definitions

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

Regulation 18: Approval and surveys of navigational systems and equipment, and performance standards.

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)).*

Regulation 19: Carriage requirements for shipborne navigation systems and equipment

2 Shipborne navigational equipment and systems
2.1 All Ships irrespective of size shall have:
.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) may be accepted as meeting the chart carriage requirements of this subparagraph;
.5 back-up arrangements to meet the functional requirements of subparagraph .4, if this function is partly or fully fulfilled by electronic means;

Regulation 27: Nautical Charts and Nautical Publications

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

While ECDIS is mentioned as an important new shipborne navigation system in the new SOLAS Chapter V, it is not listed as a mandatory carriage requirement. Instead, it is a system that can be used as an alternative (i.e., it is optional) to the traditional paper chart. However, what is stated in the new SOLAS regulation V/19, subparagraph 2.1.4 may lead to some different interpretation by national administrations about the acceptance of a ship carrying ECDIS instead of paper charts. This again might encounter problems when inspected by port state control officers around the world, if the vessel is not in possession of a document to prove that the ECDIS in operation is accepted by the Flag State.

The IMO Sub-Committee 'Safety of Navigation' (NAV) decided that there are three different options available to a national administration to address this matter: (IMO NAV, 2001):

1. The ECDIS carriage could be reflected in the safety of equipment certificate on board the ship;
2. Record of equipment for the cargo ship safety equipment certificate (Form E) that details navigational systems and equipment (paragraph 2.1) could reflect the ECDIS status, and
3. The flag state could address the matter on individual ship-by-ship basis or a holistic approach could be adopted for all ships flying its flag.

However, with **IMO RESOLUTION MSC.282(86), ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA, 1974, AS AMENDED,** which is adopted last 5 June 2009, states that Ships engaged on international voyages shall be fitted with an Electronic Chart Display and Information System (ECDIS) in a phase-in schedule from 07/2012 through 07/2018.

36.3: IMO APPROVAL OF EQUIPMENT AND INSTALLATIONS

The specifications for ECDIS consist of a set of interrelated standards from three organizations, the International Maritime Organization (IMO), the International Hydrographic Organization (IHO), and the International Electrotechnical Commission (IEC). The IMO published a resolution in November 1995 817(19) to establish performance standards for the general functionality of ECDIS, and to define the conditions for its replacement of paper charts (revised performance standards in June 2006, Res. MSC.232(82)). It consisted of a 15-section annex and 5 original appendices. Appendix 6 was adopted in 1996 to define the backup requirements for ECDIS. Appendix 7 was adopted in 1998 to define the operation of ECDIS in a raster chart mode. Previous standards related only to vector data.

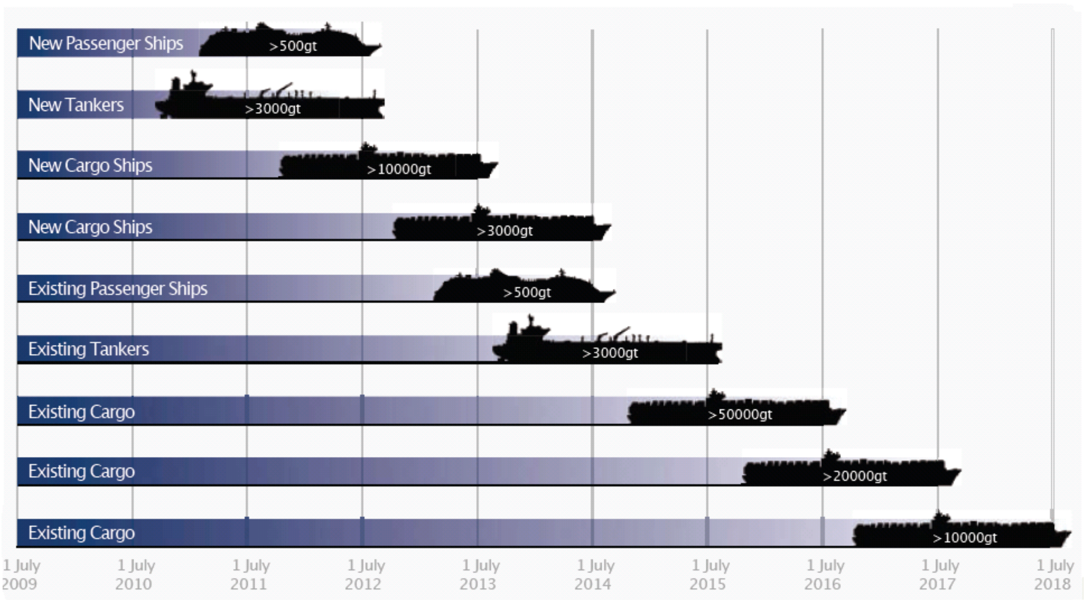
(Note: The Revised Performance Standards for ECDIS MSC.232(82) is already discussed in Lesson 1.)

36.4: IMO CARRIAGE REQUIREMENTS

- **SOLAS Ch. 5 Reg. 19.2.10 and 19.2.11 as amended by resolution Annex 1 of MSC 86/26, adopted 6/2009**
  Ships engaged on international voyages shall be fitted with an Electronic Chart Display and Information System (ECDIS) as follows:
  1. passenger ships of 500 gross tonnage and upwards constructed on or after 1 July 2012;
  2. tankers of 3,000 gross tonnage and upwards constructed on or after 1 July 2012;

3. cargo ships, other than tankers, of 10,000 gross tonnage and upwards constructed on or after 1 July 2013;
4. cargo ships, other than tankers, of 3,000 gross tonnage and upwards but less than 10,000 gross tonnage constructed on or after 1 July 2014;
5. passenger ships of 500 gross tonnage and upwards constructed before 1 July 2012, not later than the first survey* on or after 1 July 2014;
6. tankers of 3,000 gross tonnage and upwards constructed before 1 July 2012, not later than the first survey* on or after 1 July 2015;
7. cargo ships, other than tankers, of 50,000 gross tonnage and upwards constructed before 1 July 2013, not later than the first survey* on or after 1 July 2016;
8. cargo ships, other than tankers, of 20,000 gross tonnage and upwards but less than 50,000 gross tonnage constructed before 1 July 2013, not later than the first survey* on or after 1 July 2017; and
9. cargo ships, other than tankers, of 10,000 gross tonnage and upwards but less than 20,000 gross tonnage constructed before 1 July 2013, not later than the first survey* on or after 1 July 2018.

   Administrations may exempt ships from the application of the requirements from the paragraphs above when such ships will be taken permanently out of service within two years after the implementation date specified from the above paragraphs 5 to 9.



- **DNV Technical Report No. 2008-0048 CONCLUSIONS AND RECOMMENDATIONS**

The cost-effectiveness of ECDIS as a risk control option for cargo ships has been evaluated in light of updated data on global ENC coverage. As such, this study represents an update of a previous study from which results were submitted to

NAV 53 [17]. Compared to the previous study, performed in 2006/2007, a notable increase in worldwide coverage of ENC has been observed. According to data received from IHB, the number of ENCs in usage bands 3 – 6 has increased by about 33%. Based on the updated ENC coverage it has been demonstrated that between 85% – 96% of global ship traffic operates with suitable ENC coverage in coastal waters. Compared to the previous study, this represents a reduction of gaps in the global ENC coverage by about 25%. Selected representative shipping routes have been reinvestigated in detail, and most of these have also experienced an improvement of suitable ENC coverage. With the updated ENC coverage, ECDIS was proven to become cost-effective in the near future (at least by 2012) for all selected routes (one of which was not found to be cost-effective in the previous study). This study also examined ENC coverage in the world's major ports. Accordingly, nearly 88% of the 800 top ports worldwide were found to have suitable ENC coverage. Hence, it was demonstrated that the ENC coverage of major ports are extensive. The cost-effectiveness has been assessed in terms of GCAF and NCAF for new as well as existing ships. It was found that GCAF would always be higher than USD 3 million for all cargo ship types and sizes. However, NCAF was found to be less than USD 3 million and even negative for many variations of ship age and size. Basically, the recommendations and conclusions from the previous study have been supported and strengthened by this study. Notwithstanding known gaps in the global ENC coverage, this study has demonstrated that the coverage that already exists is sufficient to make ECDIS a cost-effective means of reducing the risk of grounding. Thus, the following recommendations have been substantiated with increased confidence:

i. ECDIS should be made mandatory for all passenger ships of 500 gross tonnage and upwards.
ii. ECDIS should be made mandatory for all new oil tankers of 500 gross tonnage and upwards.
iii. ECDIS should be made mandatory for all new cargo ships, other than oil tankers, of 3,000 gross tonnage and upwards.
iv. ECDIS should be made mandatory for all existing oil tankers of 3,000 gross tonnage and upwards.
v. ECDIS should be made mandatory for all existing cargo ships, other than oil tankers, 10,000 gross tonnage and upwards.
vi. Exemptions may be given to existing oil tankers of less than 10,000 gross tonnage and existing cargo ships, other than oil tankers, less than 50,000 gross tonnage when such ships will be taken permanently out of service within 5 years after the implementation dates given for iv) and v) above.

(DET NORSKE VERITAS, DNV RESEARCH & INNOVATION ECDIS AND ENC COVERAGE– FOLLOW UP STUDY (2008))

36.5: NATIONAL ECDIS CARRIAGE REGULATIONS

US regulations for charts carriage, and permissibility of ECDIS on SOLAS vessels (on international voyages)

In December 2000, the International Maritime Organization amended chapter V of the International Convention for the Safety of Life at Sea, 1974, (SOLAS) at the 73rd Session of the Maritime Safety Committee. The amendments were accepted by the Contracting Governments to SOLAS on January 1, 2002, and entered into force on July 1, 2002. These amendments, in part, added requirements for the carriage of voyage data recorders (VDR) and automatic identification systems (AIS), changed the existing tonnage thresholds used to establish carriage requirements for some navigation equipment, and allowed an electronic chart display and information systems (ECDIS) to be accepted as meeting the chart carriage requirements of chapter V. Because of these amendments, the Coast Guard will need to align its regulations in titles 33 and 46 of the Code of Federal Regulations, especially those in 33 CFR part 164, with these amendments. Until this alignment occurs, problems may result due to the inconsistencies between chapter V and Coast Guard regulations. For example, if a ship owner elects to install ECDIS, the ship ***may still be required under 33 CFR 164.33*** to carry paper nautical charts.

If a ship has an approved ECDIS installed according to chapter V, the ECDIS will be considered by the Coast Guard as meeting its nautical chart regulation in 33 CFR 164.33(a)(1), since the ECDIS meets the same navigational safety concerns as do paper nautical charts. This policy benefits the ship owner and operator by relieving them of the need to unnecessarily duplicate equipment. Under SOLAS, chapter I, regulation 12, the Coast Guard will not issue SOLAS certificates to U.S.-flag ships that are not in full compliance with the applicable requirements of the new SOLAS, chapter V. The Coast Guard will continue to exercise port state control authority under SOLAS, chapter I, regulation 19, for foreign-flag ships that are not in compliance with the applicable requirements of SOLAS, chapter V.

Existing 33CFR164.33: Charts and Publications

(a) Each vessel must have the following:

- (1) Marine charts of the area to be transited, published by the National Ocean Service, U.S. Army Corps of Engineers, or a river authority that—
  - (i) Are of a large enough scale and have enough detail to make safe navigation of the area possible; and
  - (ii) Are currently corrected.
- (2) For the area to be transited, a currently corrected copy of, or applicable currently corrected extract from, each of the following publications:
  - (i) U.S. Coast Pilot.
  - (ii) Coast Guard Light List.
- (3) For the area to be transited, the current edition of, or applicable current extract from:
  - (i) Tide tables published by private entities using data provided by the National Ocean Service.
  - (ii) Tidal current tables published by private entities using data provided by the National Ocean Service, or river current publication issued by the U.S. Army Corps of Engineers, or a river authority.

(b) As an alternative to the requirements for paragraph (a) of this section, a marine chart or publication, or applicable extract, published by a foreign government may be substituted for a U.S. chart and publication required by this section. The chart must be of large enough scale and have enough detail to make safe navigation of the area possible, and must be currently corrected. The publication, or applicable extract, must singly or in combination contain similar information to the U.S. Government publication to make safe navigation of the area possible. The publication, or applicable extract must be currently corrected, with the exceptions of tide and tidal current tables, which must be the current editions.

(c) As used in this section, "currently corrected" means corrected with changes contained in all Notices to Mariners published by the National Imagery and Mapping Agency, or an equivalent foreign government publication, reasonably available to the vessel, and that is applicable to the vessel's transit.

Reference: (***CGD 82–055, 48 FR 44535, Sept. 29, 1983, as amended by USCG–2001–9286, 66 FR 33641, June 25, 2001***)

36.6: STCW

Over the 21st - 25th June 2010, the Manila amendments were agreed. They are intended to bring the Code up to date and address perceived weaknesses through the standardization of practices. Such concerns include accidents and casualties, changes in the geographical supply of labour, inconsistent training, questions related to authenticity, and implementation of standards by signatory parties. The changes make the Code more prescriptive with a strengthened means of enforcement and control.

Within the new amendments is an increase in the demonstration of competence using simulator training and the use of modern training methodologies, such as eLearning or distance learning. There is greater prescription and emphasis on environmental awareness and regulation, leadership, teamwork and management competences, particularly for officers.

ECDIS has been included in many areas of the 2010 amendments affecting both the competence sections of Part A and the Guidance section in Part B. Some of the key changes follow.

Table A-II/1, Navigation at the operational level, requires demonstration of competence by examination and assessment of evidence on either approved simulators and/or approved training ship experience. The following is specified:

- Knowledge of the capability and limitations of ECDIS operations
- Proficiency in operation, interpretation, and analysis of information obtained from ECDIS.

Table A-II/2, Navigation at the management level, requires demonstration of competence by examination and assessment of evidence on an approved simulator, approved in-service training or approved training ship experience. The following is specified:

- Management of operational procedures, system files and data

- Use ECDIS playback functionality for passage review, route planning and review of system functions.

For OOWs and for Masters on ships of less than 500 gt engaged on near-coastal voyages, except for those who exclusively serve on ships not fitted with ECDIS, Table A-II/3, Navigation at the operational level, requires a thorough knowledge of and ability to use ECDIS. This competence is to be demonstrated through examination and assessment of evidence on approved ECDIS simulator training and/or approved in-service training.

STCW B-I specifies the training and assessment in the operational use of ECDIS. It provides guidance in the use of simulators and the need to meet the equipment performance specifications in STCW A-I/12. General direction is provided for:

- Goals of an ECDIS training programme
- Theory and demonstration
- Simulator exercise
- Principal types of ECDIS systems and their display characteristics
- Risks of over-reliance on ECDIS
- Detection of misrepresentation of information
- Factors affecting system performance and accuracy
- Setting up and maintaining display
- Operational use of electronic charts
- Route planning
- Route monitoring
- Alarm handling
- Manual correction of a ship's position and motion parameters
- Records in the ship's log
- Chart updating
- Operational use of ECDIS where radar/ARPA is connected
- Operational use of ECDIS where AIS is connected
- Operational warnings, their benefits and limitations
- System operational tests
- Debriefing exercise.

The following guidance sections have also been added to Part B:

- Section B-V/d - Guidance on application of the provisions of the STCW Convention to mobile offshore units (MOUs)
- Section B-V/e - Guidance regarding training and qualifications of masters and officers in charge of a navigational watch on board offshore supply vessels
- Section B-V/f - Guidance on the training and experience for personnel operating dynamic positioning systems
- Section B-V/g - Guidance regarding training of masters and officers for ships operating in polar waters.

Damage control guidance is also provided under B-V/2-2, describing the competence, knowledge, understanding and proficiency recommended for supporting the development of standards for the certificates of competency described in A-II/1, A-II/2 and A-III/2.

(*www.shippingregs.org/refdocs/ECDIS_Special_Report.pdf*)

36.7: FLAG STATE

Part 1: Summary of Flag State Requirements
Explanation of Columns within the Summary Table:
An asterisk (*) indicates that there is further significant or useful information in Part 2 that should be consulted. A plus (+) indicates that details have been obtained from the Flag State website.
Y = yes — N = no — N/A = not applicable — N/K = not known

Column 1:
Flag State
Name of Country. Where the nation has issued documentation either directly, or via IMO, the reference to this is included in brackets.

Column 2:
Acceptance of ENCs and ECDIS for primary navigation
"Yes" signifies the Flag State accepts the use of ENCs in ECDIS for primary navigation on all its registered vessels when used in accordance with the provisions set out in A817(19); ie with adequate back up arrangements and using ENCs. An * may indicate that approval is given on a vessel by vessel basis – see part 2 for details.

Column 3:
Back-up arrangements considered acceptable by the authority
Key:
1 - a second ECDIS device using ENCs, maintained by an independent power supply
2 - a second ECDIS device using official Raster Navigational Charts (official RNCs), maintained by an independent power supply
3 - sufficient paper charts covering the operational area
4 - other as specified in part 2

Column 4:
Acceptance of the use of RNCs in ECDIS (RCDS mode)
"Yes" signifies the flag state accepts the use of RNCs in ECDIS (in RCDS Mode) for primary navigation in areas where there is no ENC coverage at an appropriate scale for navigation and when RCDS operation is supplemented by an appropriate portfolio of up-to-date paper charts.

Column 5:
Acceptance of the use of private chart data (in ECDIS).
"No" signifies that the use of private chart data is not accepted as meeting carriage requirements and that if used in ECDIS a full set of official paper charts must be carried and used as the primary means of navigation.

Summary Table
(Reported status - March 2007)

Flag state (document reference)	Acceptance of ENCs and ECDIS for primary navigation	Acceptable back-up arrangements mode	Acceptance of the use of RNCs - ECDIS in RCDS	Acceptance of use of private chart data in ECDIS to meet SOLAS carriage requirement
Australia* (Marine Notice10/2005)	Y	1,2,3*	Y*	N
Bahamas + (Information Bulletin 51)	Y	1,3	Y	N
Barbados + (SLS14/Circ200)	Y	1,3	N/K	N
Brazil	N	N/A	N	N
Bulgaria	Y	1,2,3	Y	N
Canada*	Y	1,3	Y	N
Chile	Y	1,3	N	N
Colombia	N	N/A	N	N
Cyprus* (Circular No 26/2006)	Y	1,3	N	N
Denmark* (SLS 14/Circ180)	Y	1,3*	N	N
Estonia*	Y	1,3	Y*	N
Finland * (SLS 14/Circ201)	Y	1,3	N	N
France *	Y*	3*	Y	N
Germany* SLS14/Circ 190)	Y	1,3*	Y	N
Greece	Y	1,3	Y	N
Japan*	Y*	1,3	N*	N
Korea	Y	1,3	N	N
Liberia* (Marine Ops Note 1/2005)	Y*	1,3	N	N
Lithuania	N	N/A	N	N
Malta + * (SLS 14/Circ254)	Y	1,3*	N	N

Marshall Islands + (MG 7-41-1 10/06) *	Y*	3	Y	N
Mauritius	N	N/A	N	N
Netherlands* SLS14/Circ 191)	Y*	1,2,3*	Y	N
New Zealand*	N	N/A	Y	N
Norway*	Y	1,3*	N	N
Poland	N	N/A	N	N
Portugal	N	N/A	N	N
Spain* (SLS14/Circ283)	Y	1,3	Y	N
Sweden* (SLS14/Circ 198)	Y	1, 3	Y*	N
Switzerland	N	N/A	Y	N
Ukraine*	Y	1,3	Y	N
United Kingdom*	Y*	1,2*,3	Y*	N
USA*	N	N/A	N	N

[***Facts about electronic charts and carriage requirements 2nd edition (2007)***]

NVIC 02-03 (Federal Implementation)
In the U.S., NVIC 02-03 Carriage of Navigation Equipment by Ships on International Voyages outlines the interim acceptance for meeting SOLAS carriage requirements regarding the use of ECDIS for primary means of navigation on board foreign vessels in U.S. waters.
It is considered temporary guidance until U.S. navigation regulations are formally amended to also include U.S. registered vessels.

36.8 IMO TRAINING GUIDANCE

A detailed outline for training and assessment in the operational use of ECDIS is now included in the STCW 2010 Manila Amendments, Part B: Guidance, but is not to be regarded as required or enforceable.
The Revised Model Course 1.27 (2010 edition), will provide national authorities with a detailed training course for guidance in assessment and certification in the primary STCW competence regarding ECDIS: Maintain the safety of navigation through the use of ECDIS.

- **Obvious and Practical Need for ECDIS Training**

Unlike the paper chart, 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 care must be taken when navigating with ECDIS to avoid

- false operation;
- misinterpretation;
- malfunction;
- or over-reliance on this highly-automated navigation system.

For any type of shipboard navigation equipment, it is only as good as those who use it, and what it is being used for. In case of electronic charts, it is Mariners who will use it, in order to contribute to safe, more efficient navigation. Some Mariners have been reluctant to use electronic charts because they believe that it is a threat to their professional capability. However, technology alone will never overcome the need for Mariners, or the human element concerns that lie at the heart of navigation safety issues. An electronic chart system provides the information flow that the Mariner needs to make good decisions. Stated another way, an electronic chart is another tool to enable Mariners to perform their job better.
The list of human error leading to maritime accidents is unfortunately long. Investigations of incidents verify that it is human error that causes 80% of all accidents. Therefore, before ECDIS can be widely used and relied upon for safe navigation, Mariner training and certification is needed to address both the capability and limitations of ECDIS.

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 navigational functions of 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 (‘datum’)
  - 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
  - deficiencies of RCDS

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 information and events such as 'SCAMIN', 'overscale', 'update history', 'safety values' and 'chart usage'.
Ideally, the 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 simulator exercises should be conducted.

(What is an ECDIS Kernel?
A software library of software development kit which contains all the functions required to display electronic nautical charts in accordance with IEC, IMO and IHO ECDIS standards and provides various high and low level functions for Chart Import, Chart Work, Visualisation, Feature Query, Route Planning, Sensor Input, Navigation, etc.) (http://www.sevencs.com)

- **Differences Between RCDS and ECDIS (**SN.1/Circ.207/Rev.1)

1. The Maritime Safety Committee, at its eighty-third session (3 to 12 October 2007), adopted revised performance standards for Electronic Chart Display and Information Systems (ECDIS) and accordingly agreed to the revision of SN/Circ.207 on difference between Raster Chart Display System (RCDS) and ECDIS.
2. ECDIS has the ability to operate in two modes:
   .1 the ECDIS mode when Electronic Navigational Charts (ENCs) are used; and
   .2 the RCDS mode when ENCs are not available and Raster Navigational Charts (RNCs) are used instead.
   However, the RCDS mode does not have the full functionality of ECDIS, and can only be used together with an appropriate portfolio of up-to-date paper charts.
3. The mariners. attention is therefore drawn to the following limitations of the RCDS mode:
   .1 unlike ENC, where there are no displayed boundaries, RNCs are based on paper charts and as such have boundaries which are evident in ECDIS;
   .2 RNCs will not trigger automatic alarms (e.g., anti-grounding). However alarms and indications can be generated with the manual addition, during passage planning, e.g., of clearing lines, ship safety contour lines, isolated danger markers and danger areas to mitigate these limitations;
   .3 horizontal datums and chart projections may differ between RNCs. Mariners should understand how a chart.s horizontal datum relates to the datum of the position fixing system in use. In some instances, this may appear as a shift in position. This difference may be most noticeable at grid intersections;
   .4 a number of RNCs cannot be referenced to either WGS-84 or PE 90 geodetic datums. Where this is the case, ECDIS should give a continuous indication;

.5 the display of RNCs features cannot be simplified by the removal of features to suit a particular navigational circumstance or task at hand. This could affect the superimposition of radar/ARPA;

.6 without selecting different scale charts the look-ahead capability may be limited. This may lead to inconvenience when determining range and bearing or the identity of distant objects;

.7 orientation of the RCDS display to other than chart-up, may affect the readability of chart text and symbols (e.g., course-up, route-up);

.8 it is not possible to interrogate RNC features to gain additional information about charted objects. Whether using ENC or RNC, in the planning process a navigator should consult all relevant publications (such as sailing directions, etc.);

.9 with RNC it is not possible to display a ship's safety contour or safety depth and highlight it on the display, unless these features are manually entered during route planning;

.10 depending on the source of the RNC, different colours may be used to show similar chart information. There may also be differences in colours used during day and night time;

.11 an RNC is intended to be used at the scale of the equivalent paper chart. Excessive zooming in or zooming out can seriously degrade the displayed image. If the RNC is displayed at a larger scale than the equivalent paper chart, the ECDIS will provide an indication; and

.12 ECDIS provides an indication in the ENC which allows a determination of the quality of hydrographic the data. When using RNCs, mariners are invited to consult the source diagram or the zone of confidence diagram, if available.

Member Governments are requested to bring this information to the attention of the relevant authorities and all seafarers for guidance and action, as appropriate.

36.9: ISM REQUIREMENTS OF SHIP OWNERS AND OPERATORS

Type/model specific ECDIS training is a requirement of the International Safety Management (ISM) Code under section 6:
'The Company should establish procedures to ensure that new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarization with their duties. Instructions which are essential to be provided prior to sailing should be identified, documented and given.'

Under the terms of the ISM Code, all officers must be familiar with the equipment they are expected to use; this includes ECDIS equipment. Type specific training should be based on the actual equipment installed onboard and be provided before the officer is expected to use the equipment, for example, prior to sailing. Familiarization training can be carried out in a number of ways and ideally company policy on this should be explicitly defined within the Bridge Instruction. Many options are available, for instance the training could be:

1. An onshore course
2. Computer-based personal training, on board or onshore

3. Training mode on the actual equipment
4. A training manual designed for the purpose of familiarization, possibly supplied by the manufacturer
5. Self-familiarization of equipment with the aid of the user manual and a company-generated and approved checklist identified within the Bridge Instructions
6. Instruction on the vessel by a suitably experienced and able bridge officer to a level approved within the Bridge Instructions

The general consensus from the IMO is that officers who have undergone ECDIS generic training may not be familiar or be able to fully operate confidently an ECDIS model that they have never used or trained on before. However, debate remains within the industry on acceptable forms of providing type/model specific training. STCW does not make type/model specific training a mandatory requirement and is very much left open to the interpretation of flag states to determine training requirements.

CH. 37: EFFECTIVE NAVIGATION WITH ECDIS

When using paper charts, the navigator is actively engaged in situational awareness by the need to plot positions on the chart at regular intervals. However, this necessitates the watchkeeper spending some considerable time at the chart table plotting the position, assessing the direction of travel, estimating the course to steel and time at next waypoint, which also detracts from the watchkeeper actually looking out of the window. This is also a historical plot; it shows the position the vessel was in at some time in the past, however small an interval that may be. The ship has moved on in real time and the navigator has to adjust his calculations to take this into account.

Using ECDIS and GPS input the position of the vessel is always shown in real time.
Watchkeepers have only to look at the ECDIS display to get all the information required to navigate the vessel, giving them more time to monitor the actual situation through the window.

The look ahead facility should warn of any hazards ahead off screen but do not rely on it; always use the zoom facility to look ahead.

ECDIS has the capacity to display ARPA and AIS information for the purpose of target tracking. It is critical for mariners to recognize that if ARPA overlay is used, targets not acquired by the ARPA will not appear on the ECDIS, and targets not fitted with AIS will not appear either. ECDIS alone, therefore, should not be used as a collision avoidance tool.

ECDIS is a system that is meant to help the watchkeeper to make informed decisions. It is not infallible nor a replacement for sound judgement. The watchkeeper should be aware of information overload when using ECDIS, and set the display level accordingly.

37.1: BRIDGE FUNCTIONS INCORPORATING ECDIS

ECDIS can be used in support of many important bridge functions, but such support requires its own skill and knowledge facility, and constitutes an additional bridge function:

- Visual monitoring – effective lookout, verify visual contact
- Planning – charts, updates, routes, weather forecasts, weather routing
- Piloting – course changes, dead reckoning, vessel position, radar overlay, position history, alarm history
- Maneuvers – conditions (wind, tide, current, ice, climate data), vessel characteristics, docking, anchoring, lightering, canal transit
- Traffic – collision threat analysis, target data (ARPA, AIS, overlay tracking), verify ARPA target presentation, trial maneuver, COLREGS application, track history
- At anchor – monitor position, monitor other traffic, tidal current trends

37.2: SAFE AND PRACTICAL NAVIGATION WITH ECDIS

The Risks of ECDIS

It should be noted that the ECDIS is only a ***tool*** that helps a mariner safely and effectively navigate a ship. And due to its capability to integrate a wide variety of graphic and textual information, the electronic chart is becoming the central navigational instrument on the bridge of a ship. However, for all its capability, there are also some limitations. The electronic chart should not be totally relied upon or lead the Watch Officer into a false sense of security. Over-confidence must not result from the fact that the ship's position is automatically shown on a chart. The Watch Officer must be always wary as to how the system is actually performing in regard to accuracy and reliability. This requires an awareness of the deficiencies and risks of the overall system and its components. It must be recognized that the quality of the sum of the information is essentially dependent on the reliability of each component of data and technology. Similar to any system, an electronic chart is not infallible. It has the same shortcomings that exist in any technical device. And one of the biggest risks with the transition to ECDIS is an over reliance in the information provided.

Limitation of ECDIS

There are some limitations of the ECDIS as followings:

1. Chart Accuracy

   ECDIS provides the navigator with a tactical tool which incorporates a high accuracy positioning device. The navigator can "zoom" in on an ECDIS chart to a scale beyond the intended accuracy of the charted information.

2. Technical limitation of other devices

The accuracy is also depends on the technical limitation of other devices linked to the ECDIS, such as GPS, radar, etc. The mariner must be attentive to the source and accuracy of the position fixing device utilized by the ECDIS.

3. Information Overload

The mariner is cautioned to be wary of information overload and a very cluttered display screen. Information overload and a cluttered screen seriously degrade navigation safety for the mariner and could result in a "technology-assisted incident".

4. Familiarization of ECDIS

A mariner must invest time and effort to mastering the device prior to his first navigational watch. This will be crucial to the navigation safety of the vessel in the event paper charts are not required or available on the vessel.

37.3: NAVIGATION WITH ECDIS

Passage Planning

Effective passage planning completed by paper chart or by electronic systems is essentially the process of defining the safest navigational route in conjunction with established safety margins under which the voyage will be executed.

The passage plan should be comprehensive, detailed and easy to interpret and effectively reduce navigational risks and aid the ship and its officers to safely navigating from berth to berth.

Listed are some features of ECDIS over paper charts, and what it offers the operator in terms of functionality and time saving during the Route Planning process (Appraisal, Planning, Execution and Monitoring).

The plan should identify that the required electronic charts are available and corrected up to date. Areas where ECDIS would be operated in RCDS mode should be identified with appropriate paper charts available. The requirements of sovereign states during periods of coastal passage must be considered (IHO Website) with all relevant publications and sailing directions reviewed.

1. Appraisal – Gather Information
- is the process of gathering all information relevant to the proposed voyage, including ascertaining risks and assessing its critical areas.

a. Data

Firstly, without data an ECDIS system is useless. It is the quality of data within it that is the basis for navigational safety. It may therefore be prudent for the would-be

ECDIS purchaser to choose a quality, reliable data product first before purchasing an ECDIS that can utilize it, rather than the other way round. There are two different types of data product available for use in ECDIS, Raster and Vector charts. Raster charts are high quality scans of paper charts whereas Vector charts are databases that use 'objects' in the database to create a customized display. There are official variations of each data type, called Raster Navigational Charts (RNC) and Electronic Navigation Charts (ENC). Both terms sound non-specific but are in fact very specific:

- RNCs by definition are official charts as their official status is based on the premise that they must be constructed in accordance with IHO publication S-61 i.e. standardized and issued by a government authorized Hydrographic Office (HO).

- ENCs by definition are official vector charts as their official status is based on the premise that they must be constructed in accordance with IHO publication S-57 i.e. standardized and issued by a government authorized HO. With the existence of Private data produced by companies independent of HOs it is prudent to tread with caution in order to ensure that your data product is official. When installed with data, ECDIS systems can utilize a number of different products of both RNC and ENC format to suit the mariner's needs. The system is also capable of giving visibility of holdings so that you can see which charts are available within your system folio. This can be displayed as a list of available charts or as an overlay similar to that shown in a chart catalogue.

b. Cell & Object Interrogation

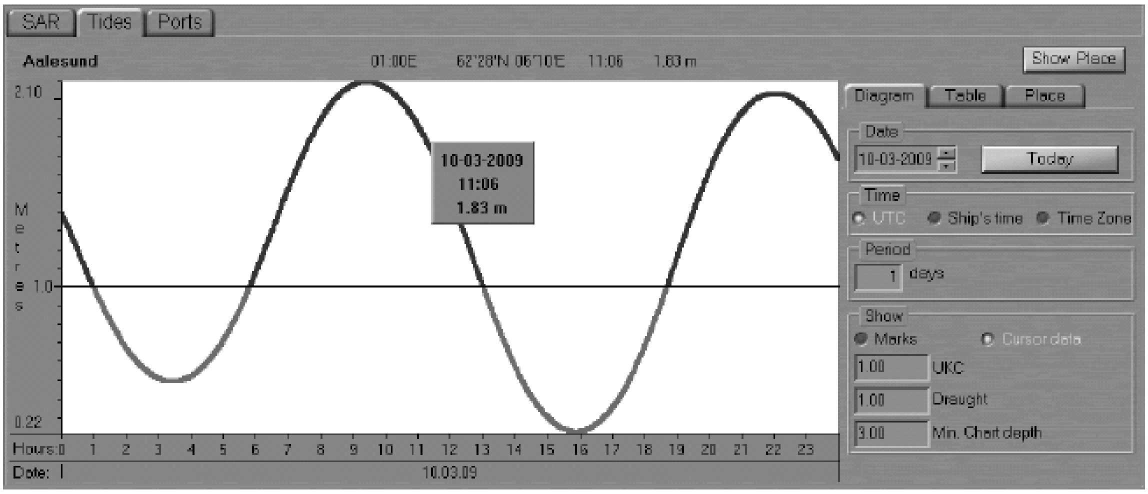
The obvious advantage when using ENCs is the ability to interrogate it to view information on the cell and objects within the cell. Effectively, it provides access to an encyclopedia of information that the operator can access. In future this may include the integration of a huge number of information sources such as Admiralty List of Lights & Fog Signals (ALLFS), for example in order that all relevant information is available at the operator's fingertips. Access to this information on ECDIS systems is not yet as user friendly as it could be. For example, it is not always possible to get a sufficient explanation of an object, particularly when interrogating ECDIS Chart1 and it can take a long time to find the information required. Many systems do not prioritize the interrogated object at the top of the list of those available in the cell and as such it can take time to cycle through the list before you find what you are looking for. It should be noted that although RNCs are scans of paper charts, when interrogated they also provide limited information about the chart such as Title, Scale, Projection and Updates, but objects within it cannot be interrogated.

c. Tidal & Port Databases

Some systems offer additional databases such as tidal curves (see screenshot below) and prediction data to aid in calculating HW, LW, tidal heights and predicted TS. However, before committing to such databases, it is worth considering where the data is from, whether it is official data and if or how it can be updated? Not all Flag States approve data provided by ECDIS manufacturers, with some stating that only Admiralty Total Tide (ATT) is acceptable (most systems are able to integrate ATT).

The environmental data in some systems may be official, in that it has been purchased from official sources, but it does not necessarily state exactly where it is from, so be careful. Some systems are able to provide their own database of worldwide ports and port information to aid the Mariner whilst others can be integrated with existing publications such as Lloyd's Fairplay. If utilizing databases provided by the manufacturer then consider how the database is updated and whether information can be updated by the user as changes occur.

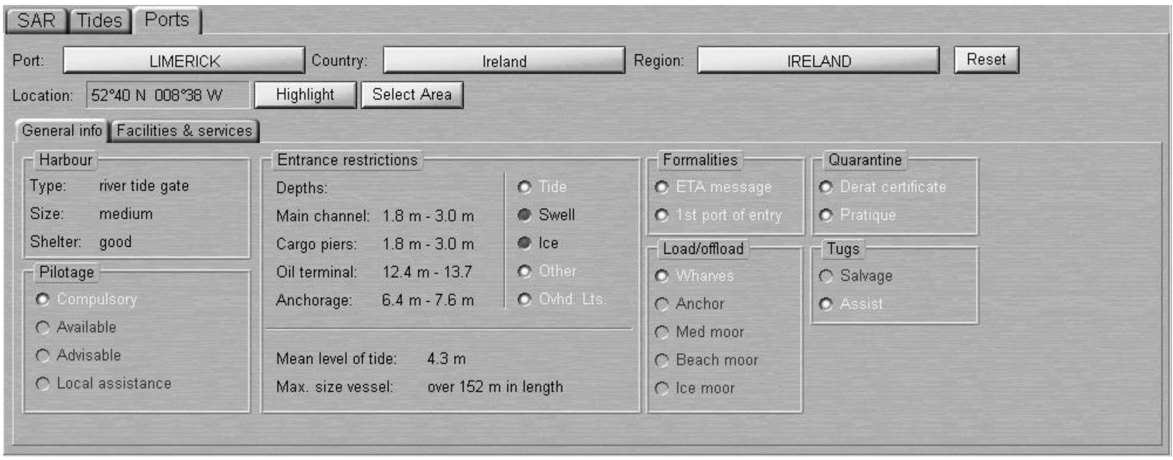
Tidal Information



The function allows the following to be displayed:

- Tidal curve specifying the tidal height (in metres and feet) depending on the time (local of ship time);
- Tidal level value which is set by the navigator proceeding from the ship draft and the minimum passage depth;
- Time intervals marked with vertical lines and highlighted with colour when the tidal height level is higher than the set one.

Port Information



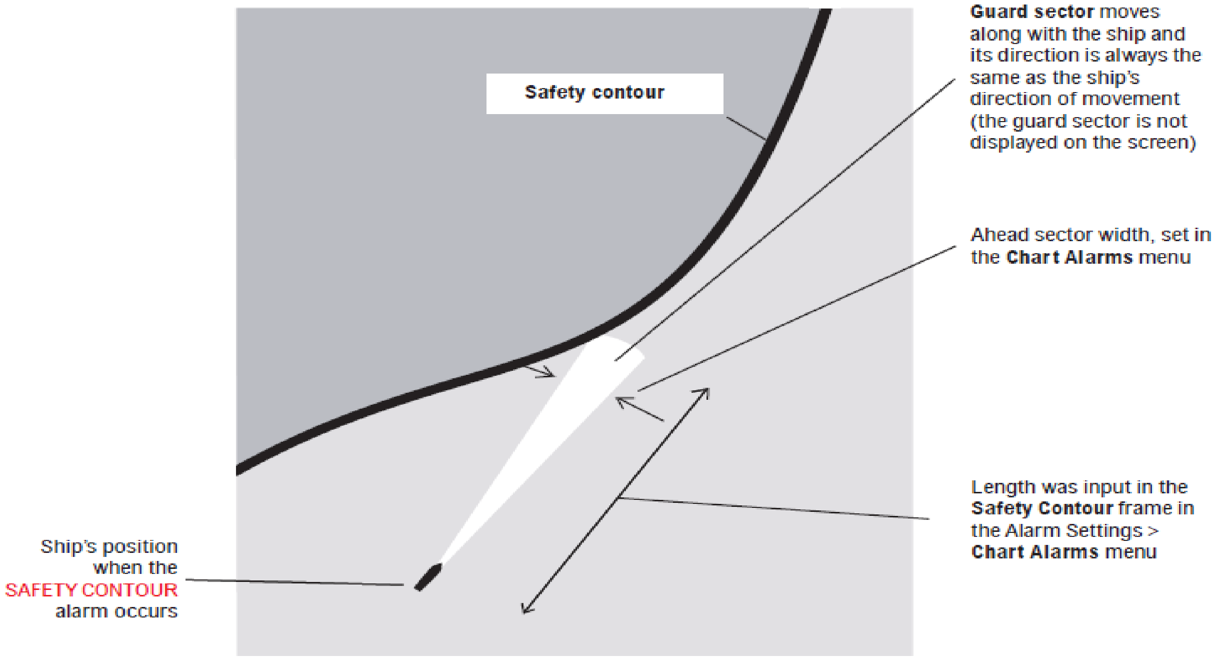
Information on the selected port is displayed in a tab in the bottom part of the ECDIS task screen, and contains the following information:

1. Name of the port, country and area which the port belongs to (in the top line of the information window);
2. Location – port location;
3. “General info” tab contains the following groups of data:
   - **Harbour** – harbour type and size;
   - **Pilotage** – the necessity or advisability of taking a pilot is given;
   - **Entrance restrictions** – list of natural factors restricting the vessels’ entrance;
   - **Formalities** – port formalities;
   - **Load/offload** – cargo handling operations;
   - **Quarantine** – quarantine procedures and documents;
   - **Tugs** – the availability the tugs for docking or anchorage assistance.
4. “Facilities & services” tab contains the following groups of data:
   - **Communications** – available communications;
   - **Services** – provided port services;
   - **Cranes & Lifts** – the availability of the cranes available and what type, and indicates its lifting power in tons;
   - **Supplies** – the availability of provisions, water, and fuel oil is listed;
   - **Other** – other information.

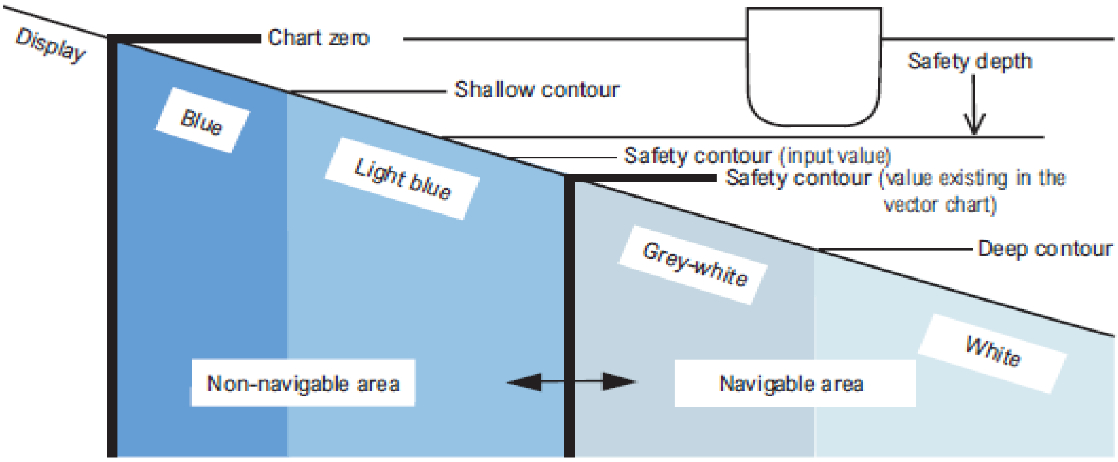
d. Safety Contour & Safety Depth

The ability of an ECDIS system to highlight a given Safety Contour based on a set Safety Depth is one of the great advantages of the system. ECDIS uses an operator configured safety depth to display a safety contour that differentiates safe water from that which is unsafe. However, the lack of contour data currently available within ENCs means the operator is not yet able to fully harmonize the Safety Contour with the Safety Depth.

The safety contour marks the division between safe and unsafe water. If the navigator does not specify a safety contour, this will default to 30m. When the safety contour is not displayed to the specified value set by the navigator, then the safety contour is shown to the next deeper contour as per the default layers in the electronic charts. Moreover, the contours may also differ between electronic charts produced by different hydrographic offices. During route planning, an indication will be made if the route is planned to cross the ship’s safety contour. At the time of route monitoring, ECDIS should give an alarm if, within a specified time set by the navigator, own ship is likely to cross the safety contour.



Safety contours should be established and information relating to weather, current, tides, chart datum, draft, speed, environmental limits, air draft, squat and general hazards such as high traffic concentrations should be prepared and made available. The concept of safety contours is a key function specific to electronic charts and further outlined in the diagram below.



2. Planning – Route Creation & Checking

After the appraisal stage, the planning officer now begins the track planning. The planning stage can be divided into three different sub-stages.

During the cuts, the planning officer will move through a quality control process from a general plan to the refined final track which will be used for navigation and approved by the master. It is essential that the built in automatic check function is used throughout the planning stages however it must be remembered that the effectiveness of the automatic check system relies on the accuracy of the safety parameters set by the user.

The final track is then often displayed with associated waypoint information and navigational notes at the central conning station or chart table for reference by the navigational officer during the Control stage of the passage planning process.

a. Route Planning

Route creation on an ECDIS can be fiddly and frustrating to start with, but when practiced makes the process much quicker. For example, if you were constructing a Great Circle route on paper charts it would be fair to say that this would require knowledge, skill and a significant amount of time! However, constructing a Great Circle route on ECDIS takes seconds as waypoints are placed at the click of a button. Moreover, there is no need to rub out your past track and re-plan or transfer waypoints from one scale of chart to another as waypoints are placed on all available charts for its position. Once the Route is complete you are presented with all the information relevant to the route. Enter your ETD and it will calculate your arrival time based on planned speed or enter your ETA and it will calculate when you need to depart. If you enter your ETD and ETA the system can calculate the necessary speed required to meet the ETA i.e. SOA. Some systems can calculate the effect of tide on your route timings and even calculate Under Keel Clearance based upon an entered draught. Once the plan is derived it can be saved and used again and again or even copied to disc and shared amongst a Fleet of ships.

However, the route planning function varies between systems with some being easier to use than others. Furthermore, some systems lack functionality with regard to producing Great Circle routes. For example, not all are able to split the curved line into individual Rhumb Lines, whereas other systems provide detailed options such as limiting latitudes, number of segments, length of segment etc. It must be noted that not all systems can calculate SOA based upon an entered ETD and ETA.

b. Route Checking

ECDIS systems have the ability to check the planned route for dangers. However, be careful as the check only looks within the Cross Track Distance (XTD) or Corridor of the route, so ensure that it is correctly configured to cover the required area. The wider the XTD the more alarms will be generated, although this is not a reason to reduce it below what is required. The check looks for set parameters which could be system defined as well as operator defined, depending on the system. If your system offers the ability to configure the search beyond set parameters, ensure that what you want the system to search for is selected. Also, when checking the route it is important to ensure that the correct display setting is selected. Another frustration when using ECDIS systems to check a route is that it may highlight the same danger on multiple occasions without recourse for the operator to clear the specific danger in one action.

When conducting the check of the route, the system will only check ENCs and not RNCs, unless there are manual alarmable constructs within the XTD. The inability of most systems to highlight gaps in ENC coverage for your route therefore necessitates that a manual check on the best scale charts be conducted for the entire route.

Note: This can be time consuming but comes highly recommended! Once the Route has been checked, additional information pertinent to the route can be added. The system can even be configured to alert the operator of such notices. Considerations at this stage are how best to display the information so that it can be clearly seen by the operator. Note that the font size is constrained on many systems and symbology is also limited.

Some ECDIS route planning tips:

1. Screen into ‘large’ or ‘planning’ screen format.
2. Orientate the chart to show the beginning and end of the route to get a ‘big handful’ feel for the route.
3. Create a blank canvas by hiding all old routes, constructs etc.
4. Begin with waypoint plotting in the general area of the start and end of the route.
5. Select either Rhumb Line or Great Circle route etc.
6. Zoom in to a more appropriate scale to modify the start and finish waypoints and ‘massage’ waypoints to account for TSS etc.
7. Ensure that you have adequate XTD for the various legs of your route to take into account the nature of the environment and expected possible deviations, lateral separation from the route and collision avoidance.
8. Check Zones of Confidence (ZOC) or Source Data Diagrams and amend the route or highlight as necessary.
9. Set Safety Depth and Safety Contour values.
10. Conduct a system check of the route at an appropriate XTD to allow for deviations, collision avoidance etc.
11. Once all alarms have been checked and verified, check the route in its entirety on 1:1 scale by manually scrolling along it.
12. Add relevant additional information and manual corrections.
13. Double check Distance / ETD / ETA and Tidal Constraints.
14. Protect the route as necessary and save a back up.
15. If updates are installed prior to sailing or during the execution of the route, ensure that the route is checked again, as updates may affect it.

3. Execution & Monitoring – Interpretation & Cross-check

a. Configuration

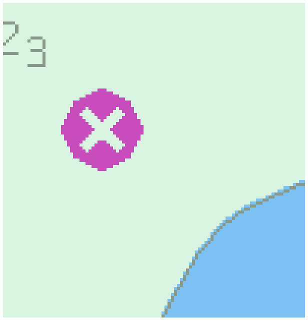
It is essential that the system is set up correctly prior to executing the route or important information will not be displayed. This relates to settings for display, data for the vessel itself and the configuration of Alarms on systems that allow it. For display purposes, the amount of information must be configured prior to executing the route and for this purpose 3 types of display must be available for use with ENCs; S52 Base, Standard and All Other.

b. SCAMIN

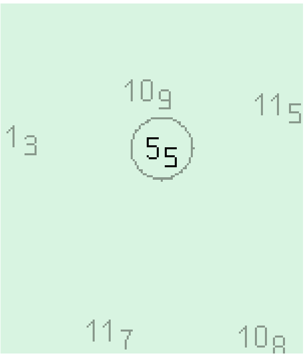
The system auto-filter means that unless you are navigating on the best scale chart, you will not see all the information available for display. Therefore, when zooming out the system will automatically deselect certain features from display such as Soundings, Lights and Topographical detail. The only way to ensure that your display is not affected by SCAMIN is to always ensure you are navigating on the best scale chart! It is therefore essential that the operator knows how to select the best scale chart on their system.

c. New Symbology

ENCs have brought new symbols that must be learnt and understood, like the two featured below.



Wreck – Dangerous wreck / Obstruction – Depth unknown / Rock – Underwater, awash rock Could be depth unknown or value of sounding known - only when interrogated. Separate to depth contour.



Sounding 5.5, reported, unreliable / therefore will not show up with safety contour

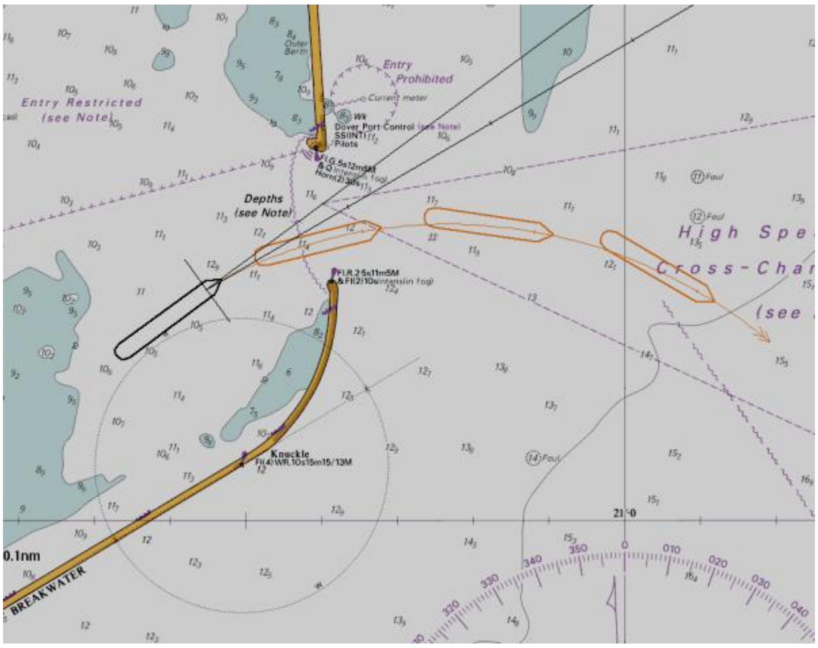
d. Fixing

The ECDIS system tirelessly fixes and records ship position based upon the primary fixing system (GPS or DGPS), whilst searching the track ahead for risky or even dangerous conditions such as Traffic Separations Schemes, charted wrecks and shoal patches. The system is also capable of loading charts automatically as you execute your passage, based upon ship position. Additionally, ECDIS also offers high levels of confidence by fusing different fixing modes (GPS/Visual/RIO) into one display. Manual fixing functionality is also provided, although some systems provide more functionality in this regard than others.

e. Precise Navigation

If the positional information is accurate, the system can be used to give valuable information about a ship's position when turning in confined conditions. Some manufacturers have developed precise navigation tools such as the Docking Mode function that allows detailed information on the forces at work on the vessel to be viewed in a separate panel.

Furthermore, functions such as the Predictor can also be used to predict the future position of the ship based upon real-time influences on the vessel such as wind, tidal stream, acceleration and deceleration and Hydro-dynamic data (see screenshot below).



4. Chart Installation & Updating

The days of updating and correcting charts in the charthouse are numbered, but do not ditch those tracings just yet. In my experience the one component of ECDIS that is guaranteed to ruin your day is the inability to update your system or install charts. Remember, it takes time and system knowledge to complete installation and updating effectively. It is worthwhile timing how long it takes your system to conduct a small and large update so that you are aware of the timescales involved. Remember, after updating the system you will need to check your route again to check for new dangers. Ensure that you are getting your weekly permit updates and that they are updated prior to any charts. Furthermore, be extremely careful when using USB sticks and CDs to transfer information between systems and computers as ECDIS systems lack virus protection. It is recommended therefore that the transfer of information between systems only occurs within the LAN and that any USBs or CDs are virus checked prior to being used. It is also prudent to back-up your system regularly. This undoubtedly needs to be carefully controlled in ship's procedures.

Reference: (**by Malcolm Instone, ECDIS Capabilities and Limitations (2011)**)

37.4: E-NAVIGATION

E-Navigation is a concept developed under the auspices of the UN's International Maritime Organization (IMO) to bring about increased safety and security in commercial shipping through better organization of data on ships and on shore, and better data exchange and communication between the two. The concept was launched when maritime authorities from seven nations requested it be added to work undertaken in IMO's NAV and COMSAR sub-committees. Working groups in three sub-committee (NAV, COMSAR and STW), and a correspondence group, as well as the International Hydrographic Organization (IHO) and the International Association of Lighthouse Authorities (IALA), are working on an e-Navigation strategy implementation plan meant for adoption in 2012. E-Navigation serves as a major IMO initiative to harmonize and enhance navigation systems and is expected to have a significant impact on the future of marine navigation.

A study conducted by UK authorities indicated that navigational errors and failures were a significant element in over half of the merchant shipping accidents that merited an investigation in the years from 2002-05. Further studies have shown both that the number of accidents is increasing, and that 60 percent of these accidents were caused by human failure. The combination of navigational errors and human failure indicate a potential failure of the larger system in which ships are navigated and controlled.

Accidents related to navigation continue to occur despite the development and availability of a number of ship- and shore-based technologies that promise to improve situational awareness and decision-making. These include the ff:

- Automatic Identification System (AIS),
- Electronic Chart Display and Information System (ECDIS),
- Integrated Bridge Systems/Integrated Navigation Systems (IBS/INS),
- Automatic Radar Plotting Aids (ARPA),
- radio navigation,
- Long Range Identification and Tracking(LRIT) systems,
- Vessel Traffic Services (VTS)
- Global Maritime Distress Safety System (GMDSS).

It is believed that these technologies can reduce navigational errors and failures, and deliver benefits in areas like search and rescue, pollution incident response, security and the protection of critical marine resources, such as fishing grounds. They may also contribute to efficiencies in the planning and operation of cargo logistics, by providing information about sea, port and forwarder conditions.

The aim was to develop a strategic vision for e-navigation, to integrate existing and new navigational tools, in particular electronic tools, in an all-embracing system that will contribute to enhanced navigational safety (with all the positive repercussions this will have on maritime safety overall and environmental protection) while simultaneously reducing the burden on the navigator. As the basic technology for such an innovative step is already available, the challenge lies in ensuring the availability of all the other components of the system, including electronic navigational charts, and in using it effectively in order to simplify, to the benefit of the mariner, the display of the occasional local navigational environment. E-navigation would thus incorporate new technologies in a structured way and ensure that their use is compliant with the various navigational communication technologies and services that are already available, providing an overarching, accurate, secure and cost-effective system with the potential to provide global coverage for ships of all sizes.

The initial definition for e-Navigation was formulated by IALA thus:

- *"The harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment."*

The IMO further describes the compelling need for e-Navigation as:

- *A clear and compelling need to equip the master of a vessel and those ashore responsible for the safety of shipping with modern, proven tools to make maritime navigation and communications more reliable and user friendly and thereby reducing errors. However, if current technological advances continue without proper coordination there is a risk that the future development of marine navigation systems will be hampered through a lack of standardization onboard and ashore, incompatibility between vessels and an increased and unnecessary level of complexity.*

E-Navigation Strategy Implementation Plan

The IMO has entrusted Norway and the Norwegian Coastal Administration to coordinate the work of developing a proposal for an e-Navigation strategy implementation plan.

Three sub-committees within the IMO - NAV, COMSAR and STW - have established working groups on e-Navigation; each group is chaired by John Erik Hagen of the Norwegian Coastal Administration. Further, a correspondence group overseen by the Norwegian Coastal Administration has an ongoing role in gathering input from national maritime administrations to proposals and decisions related to the process of establishing an e-Navigation strategy implementation plan.

The work on an e-Navigation strategy implementation plan has been broken down into several clear phases:

1. Assessing user needs
2. Constructing an open, modular and scalable architecture
3. Completing a series of studies: a gap analysis, cost-benefit analysis and a risk analysis

Core elements to the plan

The final e-Navigation strategy implementation plan will contain eight core elements, defined thus:

1. Identification of responsibilities to appropriate organizations/parties
2. Transition arrangements
3. A phased implementation schedule along with possible roadmaps
4. Priorities for deliverables, resource management and a schedule for implementation and the continual assessment of user needs
5. Proposals for a systematic assessment of how new technology can best meet defined and evolving user needs
6. A plan for the development of any technology and institutional arrangements necessary to fulfill the requirements of e-navigation in the longer term
7. Proposals on public relations and promotion of the e-navigation concept to key stakeholder groups
8. Identification of potential sources of funding for development and implementation, particularly for developing regions and countries and of actions to secure that funding.