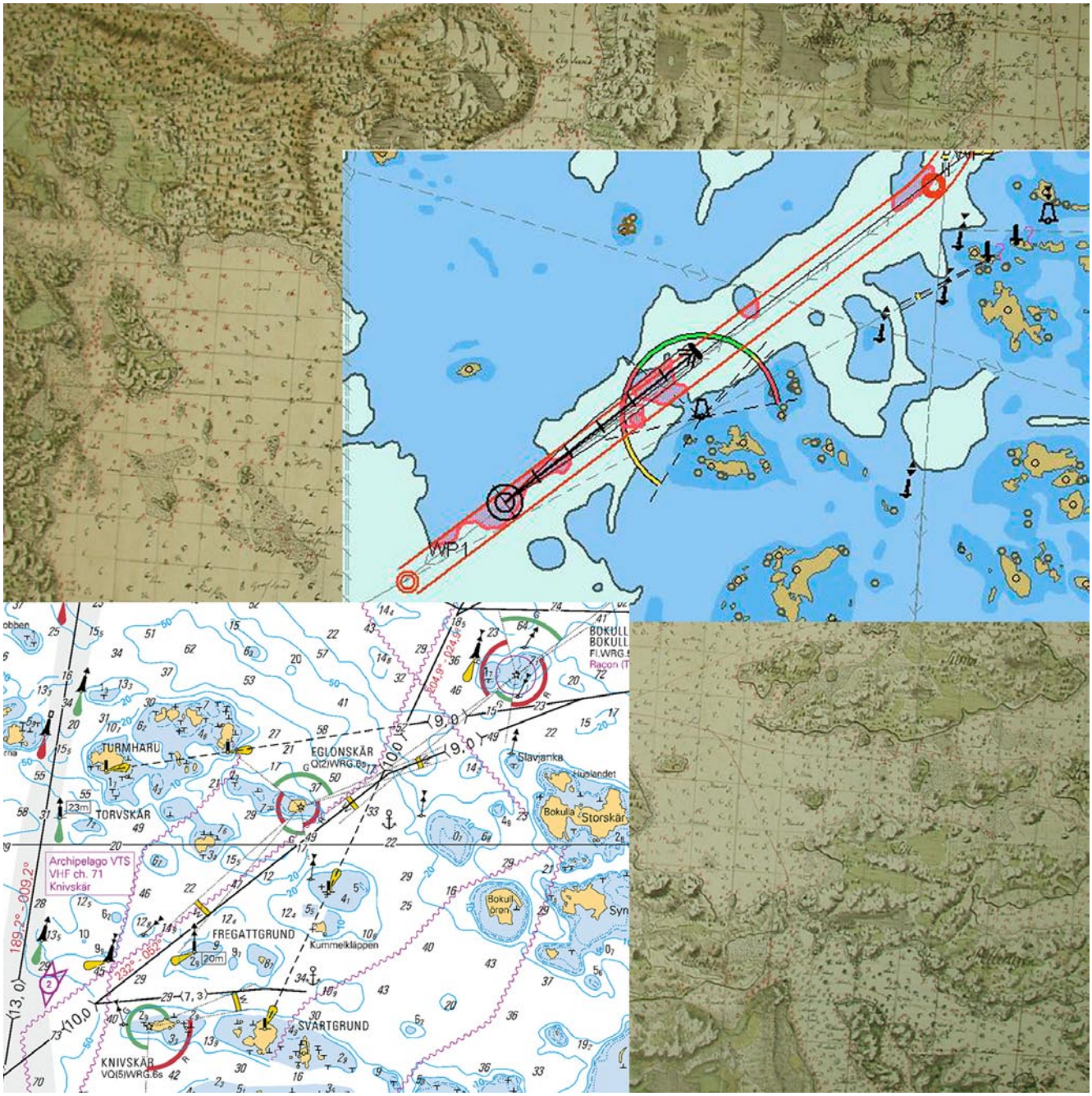
Technical details of electronic charts



Facts about electronic charts
and carriage requirements
2nd edition 2007

CONTENTS OF SECTION 4

Technical details of electronic charts

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Official electronic chart data and private chart data

Official electronic chart data are of two general types:
- Electronic Navigational Charts (ENC), and
- Raster Navigational Charts (RNC).

The inner construction of ENCs and RNCs is fundamentally different:
- ENCs are vector charts, and
- RNCs are raster charts.

The term "Official", indicates that those chart data have been produced under the authority of a government organisation – in contrast to private, i.e. nonofficial electronic chart data which might be technically of the same type but have been produced without government authority. By definition, the terms ENC(s) and RNC(s) only refer to officially issued electronic charts.

Electronic Navigational Charts (ENCs)

General principles

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

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.

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 ENCs content can be displayed as a seamless pattern in user selected scales presenting user selected chart items. Due to the limited physical size and the limited resolution of computer monitors the chart image generated from ENCs does not fully imitate the known appearance of the paper chart. This apparent disadvantage is compensated by the ENC being a database: 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.

ENC Data Format

In order to facilitate the world-wide uniformity of ENCs issued by different bodies, the IHO Special Publication S-57 "IHO Transfer Standard for Digital Hydrographic Data" isused. S-57 generally describes the standards to be used for the exchange of digital hydrographic data between national Hydrographic Office's and for the distribution of digital data and products to manufacturers, mariners, and other data users. The current version 3.1.1 (2007) of S-57 is not limited to ENC compilation, but the description of the ENC data format included in the ENC product specification and the ENC updating profile are the most important parts of the standard as it stands today.

World Geodetic System 1984 (WGS 84) is used as the horizontal datum reference for all ENCs and for GPS as well.

ENC Display

An ENC contains an abstract description of geographic entities but does not contain any presentation rules. All presentation rules to get the ENCs content displayed are contained in a separate ECDIS software module - the "Presentation Library".

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

The definition of the Presentation Library for ENCs is contained in Annex A of the IHO Special Publication S-52, Appendix 2 "Colours & Symbols Specifications for ECDIS" (current edition 3.3/2004); it's use is mandatory in all ECDIS.

The strict separation between the hydrographic information contained in the ENC, operational information taken from navigation sensors and their situation related presentation by means of the Presentation Library gives the flexibility to display the diversity of ECDIS information, e.g.:

- Physical chart information, (e.g. coastline, depth contours, buoys);
- Traffic routeing; specified areas; cautions; etc.;
- Supplementary Hydrographic Office information from light list, etc.;
- Mariner's notes; additional local chart information; manufacturer's information;
- Chartwork such as planned route; electronic bearing lines and range rings etc.;
- Own ship's position and course/speed vector; ship's heading and rate of turn; past track;
- Fix accuracy, or position check from secondary positioning system;
- Possibly, shiphandling options, based on ship's characteristics;
- Alphanumeric navigation information (ship's latitude, longitude, heading, course, etc.);
- Information from radar and other sensors,
- Information from AIS;
- Navigational indications and alarms generated by ECDIS;
- Possibly, telemetered information from shore authorities, (traffic, real-time tides etc.);
- Possibly, ice information;
- Reminders, (e.g. time to contact pilot station); and
- Possibly, a message from other displays (e.g. alarm on engine room display).

Because much experience is embodied in the paper chart, and to avoid confusion in the extended period while paper charts and RNCs as compared to ENCs co-exist, the two presentations should be similar wherever possible.

The ECDIS Presentation Library follows that of the paper chart to the widest extent possible. However, studies and early experience indicated that good visual communication between the ECDIS display and the user requires more flexibility of display than is available from paper charts. Consequently some alternative display methods are being introduced as options in the Presentation Library, e.g.:

- Displaying/removing various types of chart and non-chart information;
- Selecting standard chart display or a thinned out display, and full or simplified symbols;
- Using cursor interrogation for further detail;
- Overlaying/removing radar video or radar target information (in order to: confirm ship's positioning; aid radar interpretation; show the entire navigation situation on one screen);
- Overlaying/removing various other sensor information, or information telemetered from shore;

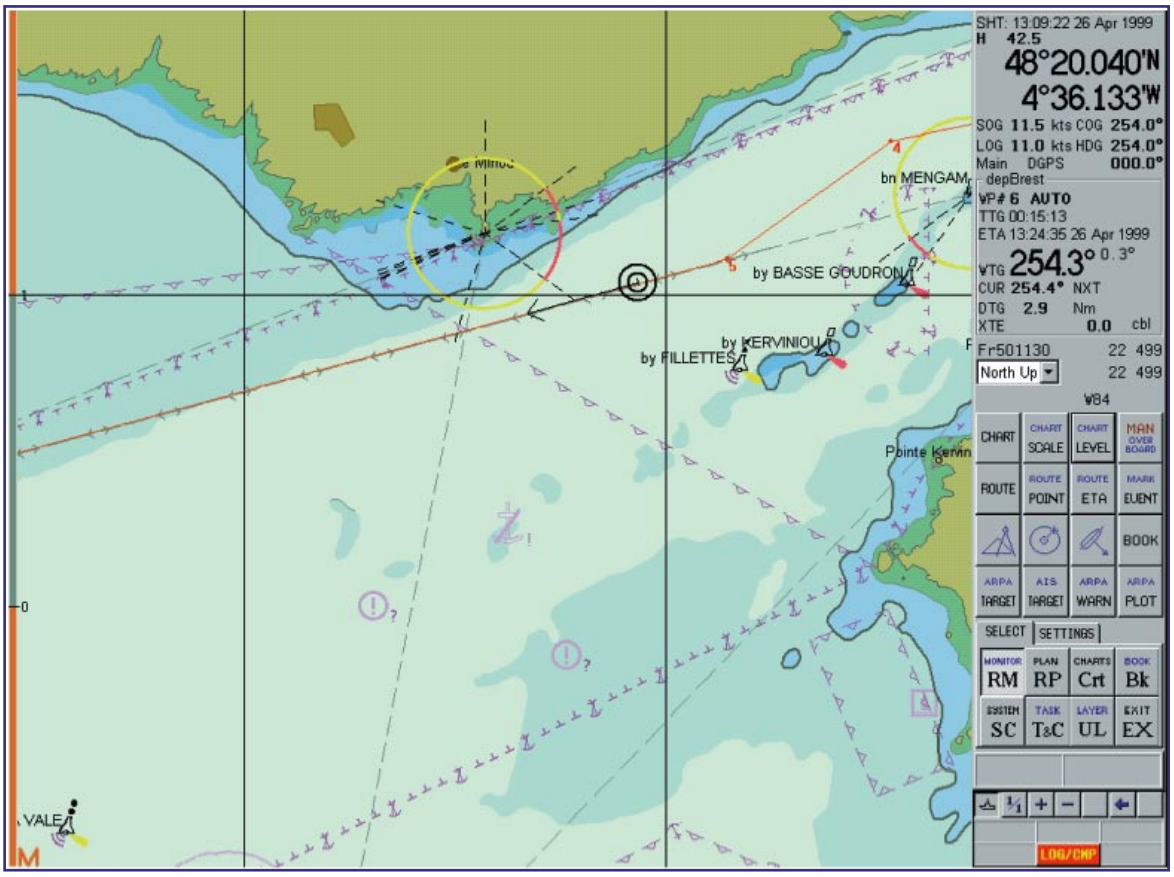
- Changing the scale or orientation of the display;
- Selecting true motion or relative motion;
- Changing screen layout with windowed displays, text information in the margins, etc.;
- Possibility of pull-down menus and other operator interaction devices being alongside the operational navigation display and so interacting with it;
- Giving navigation and chart warnings such as "too close approach to safety contour"; "about to enter prohibited area"; "overscale display"; "more detailed (larger scale) data available" etc.;
- Possibly, a diagrammatic representation of a computer evaluation of grounding danger;
- Possibly, a diagrammatic representation of the immediate vicinity of the ship to aid in close quarters manoeuvring;

The ambient lighting on the bridge varies between the extremes of bright sunlight, which washes out information on the display, and night, when the light emitted by the display has to be low enough that it does not affect the mariner's night vision.

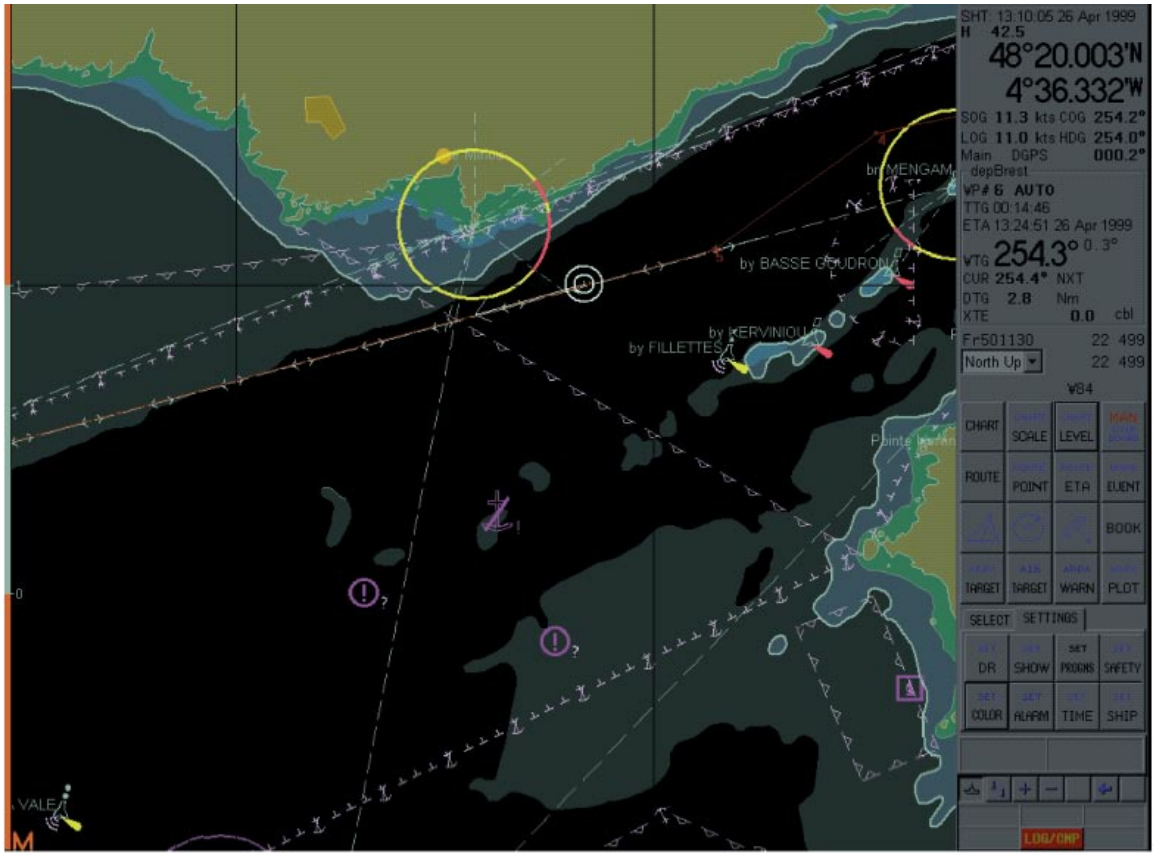
The colour and symbol specifications of S-52 have been designed to meet these difficult requirements rather than less demanding normal day conditions. Because the ECDIS display uses emitted light, compared with reflected light for the paper chart, ECDIS must switch to a negative image of the chart at night, using a dark background in place of the white background of the paper chart, in order not to impair night vision.

Three predefined different colour schemes are therefore provided:
- Day (white background)
- Dusk (black background)
- Night (black background)

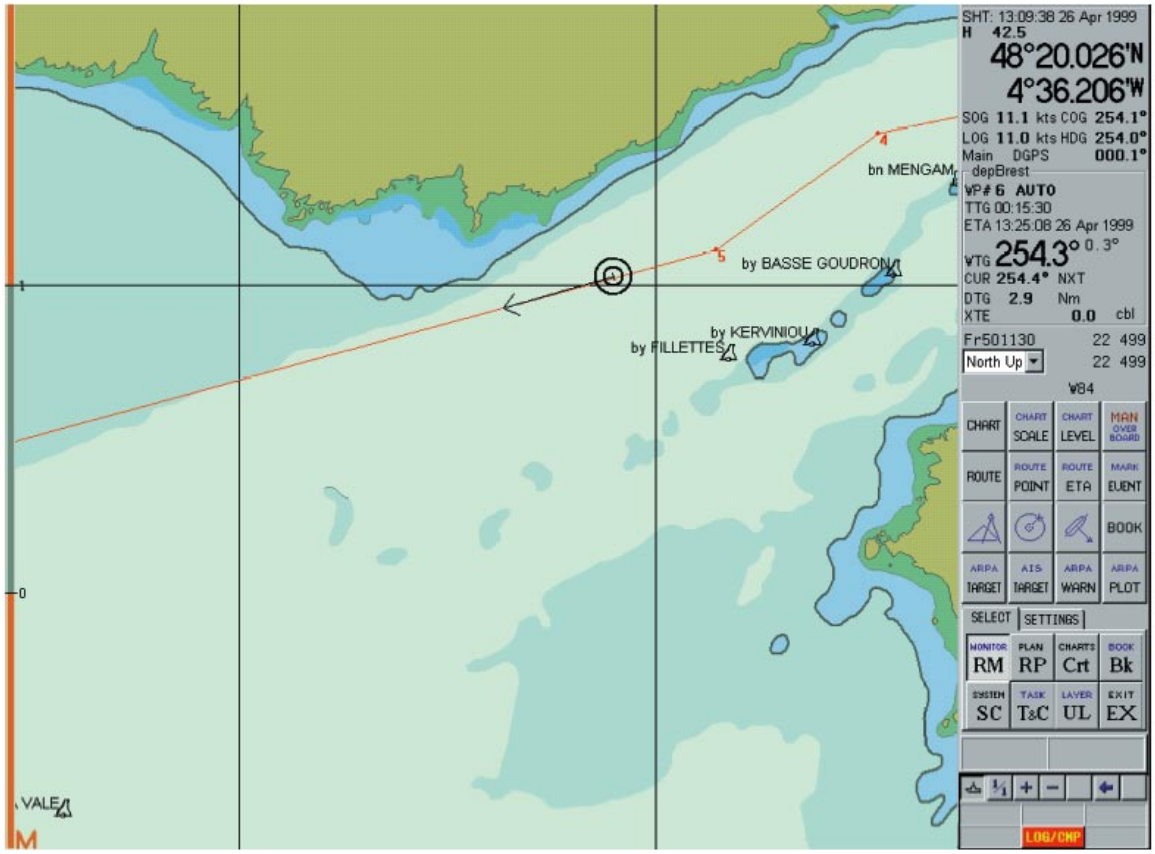
Below are illustrated two different colour schemes and the three standard selections of content i.e. Standard Display, Base Display and Full Display.



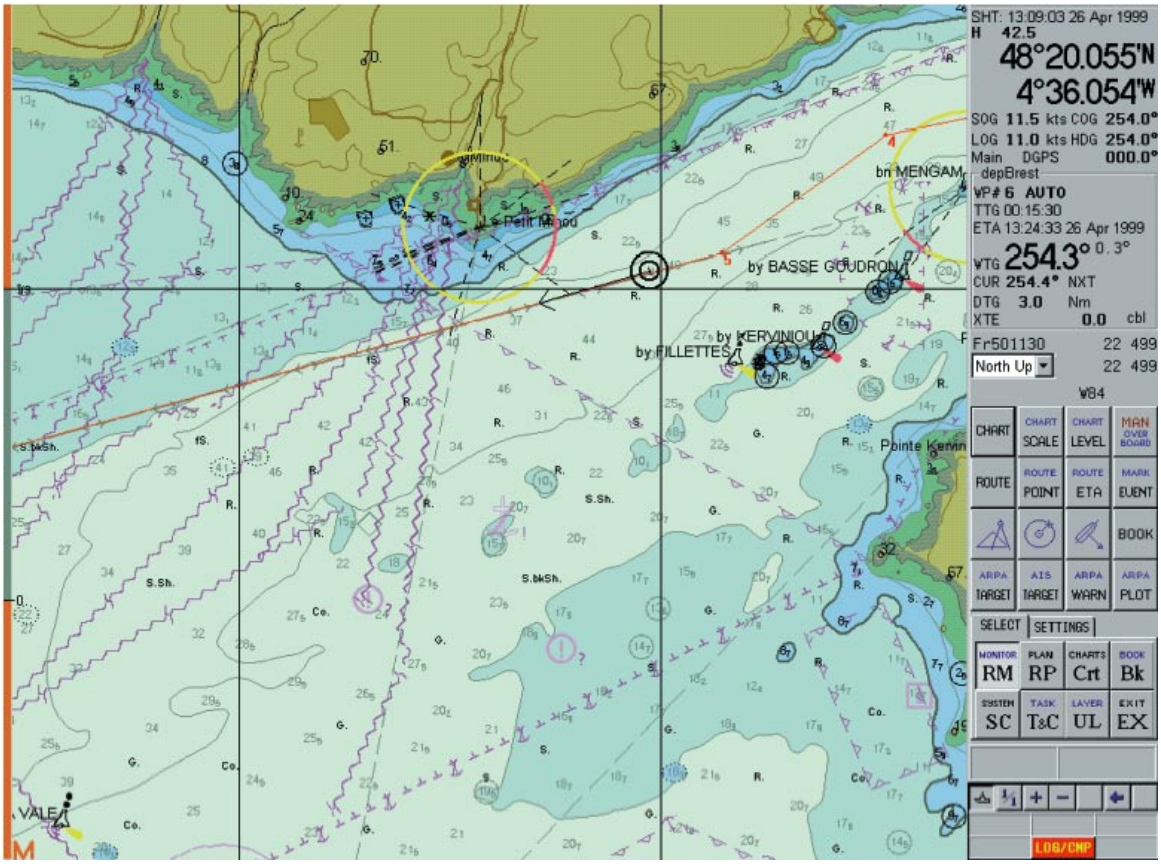
Picture 1: Standard Display, day



Picture 2: Standard Display, night



Picture 3: Base Display, day



Picture 4: Full display, day

Use of ENCs in ECS

It should be noted that many ECS are able to use ENCs.

ENC Distribution

The provision of a timely, reliable worldwide uniform ENC data distribution service is a major organisational challenge. The IHO developed the WEND (World-wide Electronic Navigational Chart Database) concept to meet these requirements. WEND consists of two components:

- A charter describes the principles governing the cooperation between Hydrographic Offices e.g.:

  o By definition, the organisation responsible for charting of an area is also responsible for the ENC production;

  o The relevant standards, especially S-57 must be observed; and

  o The rules of a recognised work quality assurance system (e.g., ISO 9000) should be applied to data production.

- A conceptual schema describes a network of regional centres.

  o Each so-called Regional Electronic Chart Co-ordinating Centre (RENC) takes over the responsibility in its area for the collation of ENCs and up dates for the region;

  o Through the exchange of the regional datasets and their updates between all RENCs each RENC can offer an identical global dataset for ECDIS; and

  o RENCs do not deliver ENCs directly to ships. RENC customers are commercial chart data distributors who - in analogy to paper chart distribution - tailor individual sets of chart data for the special needs of a shipping company or a particular ship.

To date, two RENCs – Primar Stavanger, based in Norway and IC-ENC, based in the United Kingdom, are in operation. However, it has to be noted, that the WEND concept has not been fully adopted through all ENC producing nations yet. A number of nations are still distributing their ENCs individually either through chart data suppliers or directly.

Principally, WEND focuses on the supply and distribution of ENCs by facilitating the establishment of services intended to satisfy the SOLAS carriage requirement for up-to-date charts. Within this primary purpose, ENCs are to be distributed in the encapsulation described in the S-57 Standard. However, such "plain" S-57 encapsulated ENCs may become easily subject to unauthorised amendment or illegal copying.

IHO has therefore issued the special publication S-63 "IHO Data Protection Scheme" as Standard for protection of ENCs by encryption.

Encryption is a complex technical procedure: S-63 defines security constructs and operating procedures for the RENCs/chart data distributors and provides specifications that allow navigation equipment manufacturers to build S-63 compliant ECDIS. S-63 is already in use for ENC distribution and is supported by the noted two RENCs. Most major ECDIS manufacturers have implemented decryption procedures in conformance with S-63 within their systems.

What is a SENC?

An ECDIS does not process the ENC content directly for the matter of display. ENCs in S-57 format are optimised to absorb the Hydrographic object information but this structure is not adequate for the fast generation of the resulting computer image on the screen.

In order to get efficient data structures that facilitate the rapid display of ENC data, ECDIS firstly converts each ENC from S-57 ENC format into an internal format called SENC – System ENC – which is optimised for chart image creating routines.

Such routines are not standardised; they are part of the individual software know-how of the ECDIS manufacturers. Consequently the SENC format differs between the ECDIS of different manufacturers. In contrast to the common uniform ENC format the SENC format is proprietary for each ECDIS manufacturer.

SENC delivery

The WEND system has established an optional distribution mechanism called SENC delivery. This is in addition to the standard ENC distribution. In this case, the RENC delivers the ENCs to an authorized chart data distributor who then performs the ENC-to-SENC conversion (that otherwise would have to happen inside the ECDIS), and deliver the SENCs to the end user.

However, it is up to the individual Hydrographic Offices to decide whether they allow the ENCs for their waters to be distributed in SENC format.

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 »

What scale should an ENC be displayed at?

During production, ENCs are assigned a compilation scale based upon the nature of the source data they are based on, and are allocated to a navigational purpose band related to this. As shown in the table below there are 6 navigational purpose bands (scale ranges are indicative only).

Table 1: Suggested assignment of navigational purposes to scale ranges

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

To facilitate the display of the radar overlay on ENCs, Hydrographic Offices are recommended to set the compilation scales of their ENCs to be consistent with the standard radar range scales as shown in the following table:

Table 2: Radar range / standard scale

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

How are ENCs named?

Each ENC is identified by an 8 character identifier e.g. FR501050. The first two characters indicate the producer e.g FR for France, GB for Great Britain (a complete list of producer codes is included in the IHO standard S-62). The third character (a number from 1 to 6) indicates the navigational purpose band (as shown in the table 1). The last 5 characters are alpha- numeric and provide a unique identifier.

Updating ENCs

In principle the generation and distribution of regular updates uses identical organisational structures as for the production and distribution of ENCs described above. Their frequency is usually synchronised with the chart corrections promulgated with national Notice to Mariners for the affected sea areas.

Updates may reach the ship via different ways depending from the capabilities of the service provider and the communication facilities onboard:
- On data distribution media, e.g. CD;
- As e-mail attachment via SATCOM; and
- As broadcast message via SATCOM plus additional communication hardware.

Raster Navigational Charts (RNCs)

General principles

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

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

As a digital copy of the original paper chart, a RNC has no intelligence and other than visually, cannot be interrogated for e.g. automatic route checking or hazard warnings; however some of these limitations can be minimised by manual user input to the ECDIS.

RNC data format and production

RNCs are normally produced by digitally scanning the stable colour bases used in the multi-colour printing process. Unlike ENCs there is not a single accepted format for RNCs. The main formats are
- BSB (used by USA, Canada, Cuba and Argentina), and
- HCRF (used by UK, Australia and New Zealand).

RNC Display

- RNCs are designed to be displayed at the same resolution as that which they are provided. Excessive zooming in or out of the same image seriously degrades the RNC image. RCDS allows charts of appropriate scale to be displayed; when the user wants to zoom in then a larger scale chart will be displayed and similarly on zooming out a smaller scale chart will be used;

- Orientation of the RCDS display to other than north-up (e.g. course-up or route-up), may affect the readability of chart text and symbols;

- RNCs incorporate very similar colour palettes to the day/night colours used by ENCs. It is mandatory for RCDS to have the capability to use different colour palettes;

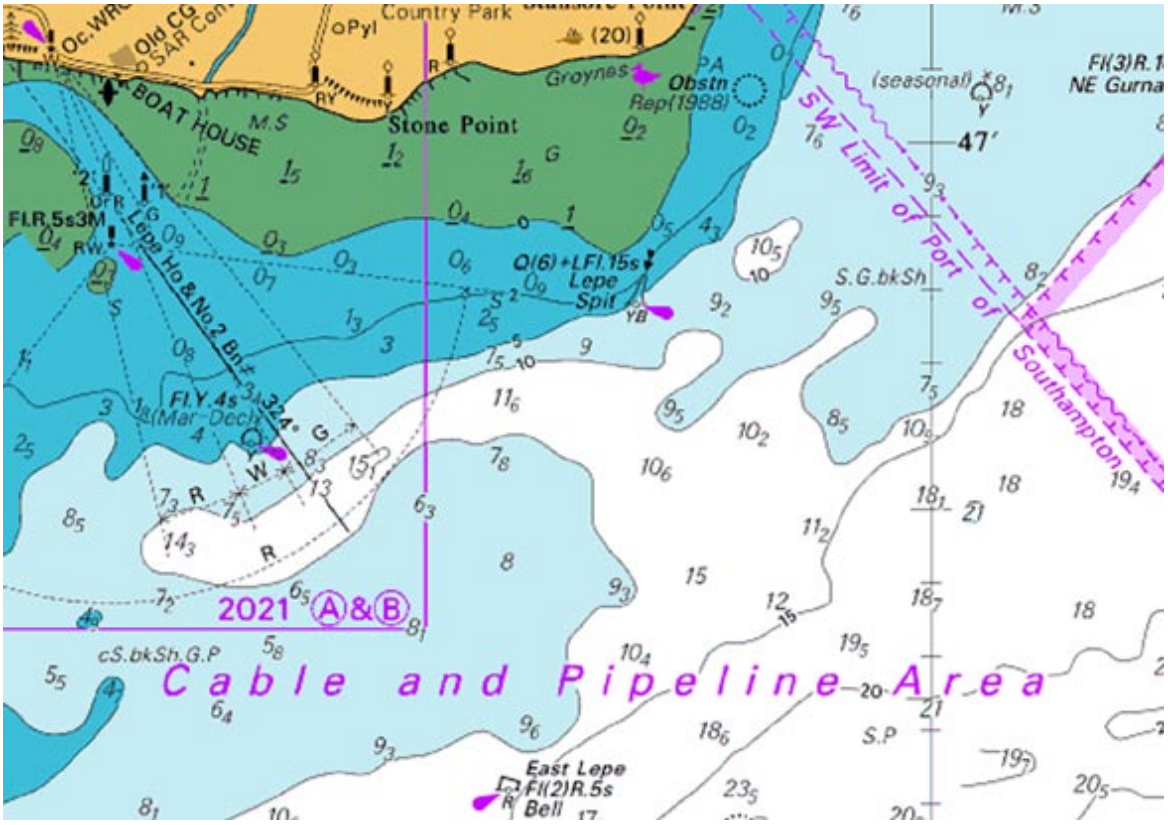
- RNCs are treated as individual charts (not seamless like ENCs). However, it is possible for ECDIS to automatically load adjoining chart based on the meta data provided;

- ARPA radar targets can be overlaid onto an RNC. It is also possible for a radar video image to be scaled to fit the RNC. Scaling the RNC to fit the radar video image is unsatisfactory as this is likely to result in a degraded chart image; and

- RNCs include significant meta data to allow the ECDIS to make maximum use of the image. For example chart notes and tide panels may be accessed directly by the RCDS rather than the user having to scroll to the appropriate area of the chart.

RNCs maintain the horizontal datum of the paper chart from which the RNC has been derived. Mariners should understand, how the chart horizontal datum relates to the datum of the position fixing system. In some instances, this may appear as a shift in position. (Any differences will be most noticeable at grid intersections and during route monitoring). Where the difference between the local horizontal datum and WGS 84 is known, an adjustment should be automatically applied by the ECDIS. If the horizontal datum of the paper chart from which the RNC is produced is not known then it is not possible to relate GPS positions accurately to the RNC; IMO SN circular 255 has been issued to alert users to this problem.

Below are illustrated Day and Night colour schemes of a RNC



Picture 5: RNC Display, day

Picture 6: RNC Display, night

RNC updating

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

Private chart data

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

Private chart data is often not updated with the same regularity as official data. The suppliers normally base their products on official charts and data (supplied by HOs under licence); this means that the updating of their charts depends on the availability of the updated official chart product. Consequently there is frequently a delay; sometimes considerable, in updates being provided.

It should be noted that chart data published by private companies is not quality controlled by a Government organisation and therefore the product liability is entirely the responsibility of the producing company. This is in contrast to official charts where the product liability rests with the government of the producing nation.

In 2003 ISO issued a specific standard for private chart data; this standard was produced on the initiative of the industry: ISO 19379 applies to both private vector charts and to private raster charts. Chart data certified according to ISO 19379 is now available on the market.

Private chart data, regardless of the format in which it is supplied to the market or ISO certification does not meet the requirements specified by the IMO Performance Standards for ECDIS and thus does not meet carriage requirements.

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

Examples of companies producing private vector charts :
C-Map (eg NT+)
Euronav (eg LiveChart)
Garmin (eg BlueChart)
Navionics (eg Gold, Platinum)
Transas (eg TX-97)
Navicarte

Examples of companies producing private raster charts:
Maptech,
Mapmedia
NDI,
SoftChart