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# THE ELECTRONIC CHART AND ITS PROVISIONAL SUBSTITUTES

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## ABSTRACT

This article compares ECDIS (Electronic Chart Display and Information System) with other electronic chart systems based on raster data obtained by scanning paper charts. It separates circumstancial or accessory factors - such as the cost, availability of data, and legal status - from the specific differences between the systems as regards functionality and performance. ECDIS is a dynamic information system, capable of integrating information from various sources onto a single display. Thus this system will completely change navigational practices. Raster systems are far from possessing all these capabilities and must be considered to be substitutes or fore-runners of ECDIS, functioning on a provisional basis at least until such time as a significant amount of authorized vector data covering the main areas of navigation are available for ECDIS.

## INTRODUCTION

The definition of the specifications for the future electronic chart by the competent Organizations [(Hydrographic Offices, the International Maritime Organization (IMO), and the International Hydrographic Organization (IHO)] is an unavoidably slow process, in view of the ambitious nature of the project. The constitution by Hydrographic Offices of a base of digital data for ECDIS (Electronic

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Chart Display and Information System) is a long and costly operation. It is therefore not surprising that mariners - and above all manufacturers anxious to sell "electronic charts" - show some impatience with regard to the official authorities. Thus private companies have begun to digitize nautical charts, totally or partially, very often without the agreement of the Hydrographic Offices publishing charts and without the authorization - which is, however, essential - of the Hydrographic Offices which carried out the relevant original surveys. [2]

At the present time, no electronic chart exists corresponding to the definition of ECDIS, i.e. able, notably, to be a substitute for the paper charts required to be carried by the SOLAS Convention. However, it is relevant to note the existence of ECDIS prototypes which have already been used in trials in well-defined areas.

A new event has occurred which modifies to some extent a situation where private initiatives were the most strongly in evidence. Since 1993, the British Hydrographic Office has launched an operation to digitize its own charts by raster scanning (raster data) and is progressively making ARC (Admiralty Raster Chart) products available to users.[3]

The definition of the raster form will be given later. In principle, the ARC collection was to include 1 500 charts by early 1996. Thanks to ARC, an exact copy of the paper chart - or, more exactly, of a portion of the chart that will fit into the display screen - may be displayed. Naturally, the British Hydrographic Office indicates clearly that the ARC product is not likely to provide information for ECDIS. Nevertheless, in the mind of the mariner, ARC has a special virtue : it represents data from a Hydrographic Office which, if up to date, give the same guarantees of safety as the traditional paper chart of which they are a true copy.

During NAV 95, organized by the Royal Institute of Navigation, which was held in London, 7-9 November 1995, the electronic chart was the subject of a number of papers. Notably presented there were the respective advantages and disadvantages of ECDIS and of electronic navigation systems based on raster chart data. These papers call for comments, which are intended to enlighten the reader as to the nature of the real electronic chart (ECDIS) and that of the substitutes for it that are currently being proposed.

[2] For a given chart, these Offices are not necessarily one and the same. Indeed, a Hydrographic Office may produce charts of areas outside its national waters and use for that purpose data shown on the charts of other Hydrographic Offices who are the real owners of the data they have collected at sea.

[3] To designate the system set up, the British Hydrographic Office uses the term ARCS (Admiralty Raster Chart Service).

## BRIEF DEFINITION AND FUNCTIONAL CHARACTERISTICS OF ECDIS

ECDIS is a system consisting of hardware, software, and a hydrographic and nautical data base, which makes it possible to display permanently on screen the ship in its nautical environment. It is not simply the electronic reproduction of a chart, but - as its name implies - a real system for presenting varied information, in particular, cartographic features, the use of which will considerably change the work of the navigator.

The performance and functional characteristics of ECDIS have been established by the IMO in liaison with the IHO. The ECDIS Performance Standard was adopted in November 1995 by the 19th IMO Assembly. The specifications for the cartographic content and its display on ECDIS form the subject of a Special Publication of the IHO (S-52).

The principal functional characteristics of ECDIS are as follows:

1) The instantaneous position of the ship[4] is displayed continuously on the screen, along with a set of cartographic information. It is then possible to combine instantaneously the ship's position and the cartographic information (for example, one can obtain immediately the azimuth and the distance of a landmark which one fixes on the display). All the navigation problems which are solved using the paper chart can be solved very rapidly using ECDIS.

2) ECDIS contains - or will contain - supplementary information in addition to what appears on the paper chart and which the mariner traditionally finds in other documents such as Lists of Lights and Sailing Directions.

3) ECDIS makes it possible to introduce dynamic information on the environment as a function of time. Thus the system will be able to take the tide into account in order to change from isolated soundings and isobaths to real depths.

4) In order to have a clear view of the situation, the mariner can select only the information he really needs in his current situation. But certain cartographic information deemed essential for safe navigation in all circumstances are permanently displayed. This is the minimum content.

5) Alarms and warnings are sent to the mariner when he crosses a certain isobath or approaches a danger, or a prohibited or regulated area.

[4] Presumably acquired by radioelectric means (GPS, LORAN C, ....).

6) It is possible to display on screen a processed radar image and cartographic information from ECDIS. In this way, ECDIS and ARPA can be combined.

7) Changes of scale may be effected, and particularly enlargements or blow-ups (zoom).

8) The updating of the data base is done automatically by occasional corrections transmitted by satellite or by the dispatch of complete new editions.

Thus, ECDIS is a dynamic navigation system capable of integrating information from many sources (nautical documents, radar, radio positioning systems, ....) into a single display.

## FORM OF DIGITAL DATA FOR ECDIS

Certain ECDIS performances are largely conditioned by the form in which the digital hydrographic data at the base of the system are presented. These are vector data. This means that the cartographic objects or structures are entered and stored individually. Storage is in the form of position points, lines, or areas. Each structure is defined by a series of geographic coordinates which pinpoint it in the single reference system (WGS 84) along with its attributes which indicate its characteristics. These *data*, called *intelligent data*, can be called upon for any use and in particular in order to produce a display on screen. The data base is organized in layers, each of which contains a certain type of information, which allows, in particular, for selective display (functional characteristic No. 4).

## RASTER FORM

The paper chart is analysed "line by line" by means of a scanner, which allows for the storing, in chronological order of detection, of a set of almost discrete items of information (pixels) to each of which a colour is attributed. These ordered data (raster data) subsequently allow for the restitution on screen of the electronic image (matrix image) of the chart, or, more precisely, of a portion of the chart within the limits of the dimensions of the display screen. No cartographic object is identified; no information can be called for from the data base. These data can only serve to re-copy a graphic model faithfully on the display screen. Such *data* are referred to as *silent*.

In what follows we will call, for reasons of simplicity, *raster system* (matrix system) any system of electronic presentation of charts using digital data in raster form (rastered data). Thus the systems which use ARC are raster systems. They are referred to in English by the acronym RCDS (Raster Chart Display System).

## COMPARISON BETWEEN ECDIS AND RASTER SYSTEMS

In listing the advantages and drawbacks of each system, it is necessary to distinguish what is purely commercial or accessory from what relates to the intrinsic qualities and performances of the systems. Rather than presenting in parallel and in an independent manner the advantages and drawbacks of each system, it is better to compare two systems based on a set of definite criteria.

It goes without saying that it is preferable to navigate with a raster system using complete and reliable data, i.e. data guaranteed by a Hydrographic Office, rather than with a system resembling ECDIS, functioning with vector data that are incomplete or non-guaranteed. I will, therefore, in what follows, leave aside such dangerous systems and restrict myself to comparing ECDIS with raster systems whose data are provided by a Hydrographic Office.

The fact that raster data are already available for a large number of charts, whereas vector data for ECDIS are for the moment rather rare, is merely a provisional advantage for raster systems. Certainly it is easier, much faster, and therefore less costly, to constitute a raster data base rather than a vector data base. But comparison only of cost and production time cannot constitute an argument for choice : the performance of the systems must be taken into account. We know, too, that the notion of price in a matter of service to the public can only be relative. Let us remember that the paper chart is sold for a price which does not take into account the costly operations at sea and one which covers only part of the cartographic work properly speaking. This is a contribution made by States to the safety of navigation. The hardware and software for electronic navigation systems produced by commercial manufacturers are sold at market prices, excluding the data bases which supply them.

We may note other slight arguments in favour of the raster system. The mariner would consider it an advantage to find on the display of such a system the exact copy of the paper chart with which he is so familiar. Such an attitude can only be explained if the mariner is unaware of the potential of ECDIS, which is much more than a chart, as it is a dynamic system of information and integrated aid for navigation control. In the same spirit, supporters of raster systems refer to the advantage of the shorter learning period required in order to use such systems compared with the time necessary for correct exploitation of ECDIS. It is true that ECDIS introduces considerable changes in navigational practice - this is, in fact, what gives it its value! When radar was introduced, it was also necessary to train personnel to use it correctly. But it has been found, for some time now, that it is quite normal to devote time to training in the use of such equipment which has made an extraordinarily great contribution to the safety of navigation.

It is correct to say that liability for hydrographic and nautical data (responsibility for the product) is easier to establish when raster data supplied by a Hydrographic Office are used, which exactly reproduce its charts and when such data undergo no modification by the software produced by the manufacturer of the

raster system. But the legal difficulties concerning liabilities involved in ECDIS are surmountable and are not pertinent for the mariner.

After having mentioned the circumstancial arguments which have been developed with regard to ECDIS and raster systems, it is necessary to compare the functional characteristics and performances of the two types of system. As, obviously, nobody puts forward any aptitude in the raster system which is not present in ECDIS, we will establish the comparison on the basis of the functional characteristics of ECDIS previously listed.

**Functional characteristic 1:**

In the ECDIS system, the positions of cartographic features are exclusively referred to WGS-84, which is the geodetic system to which GPS is referred and to which, in the future, all other means of positioning will be referred. Raster charts are, like the paper charts on which they are based, referred to a wide variety of geodetic systems. When correspondence between the geodetic system of the chart and WGS-84 is known, raster systems take this into account in a way that is clear for the mariner. Hence, raster systems enable the ship's position to be displayed at the same time as the cartographic background.

Thus functional characteristic 1 is achieved with the raster system, though more laboriously than with ECDIS.

**Functional characteristic 2:**

The information contained in the raster data base is strictly confined to the contents of the paper chart. Functional characteristic 2 is therefore an advantage belonging exclusively to ECDIS.

**Functional characteristic 3:**

In the raster system, the graphic features are not identified as cartographic objects. Thus, a sounding or an isobath are not recognized. It is therefore not possible to vary depths as a function of the tide. Functional characteristic 3 is reserved for ECDIS.

**Functional characteristic 4:**

For the reasons just mentioned, no selection of cartographic information is possible with the raster system, which constantly shows the whole of the contents of the paper chart. However, for areas of dense traffic or in narrow waters where regulations abound, the chart is often overloaded and therefore difficult to read. That is a major drawback of charts, for which ECDIS provides a decisive remedy. It has been claimed that the rigidity of the raster chart system is an advantage in that it avoids the possibility of the mariner removing by mistake things that are vital for the

safety of navigation. In reality, ECDIS gives the same guarantee thanks to the *minimum content*.

**Functional characteristic 5:**

In a raster system, it is not possible to set off alarms when approaching certain charted lines, as silent data do not allow for this.

However, a partial remedy for this situation has been found by manufacturers by overlaying the raster system with a vector layer made up of objects generated by the user (without automatic interaction between the two layers). Thus the user can define the limits of areas, routes, bearings or distance circles centred on dangers or landmarks. This arrangement makes it possible, if necessary, to generate alarms (when straying from the route, for instance). But all this is far from the facilities and automated responses offered by ECDIS.

**Functional characteristic 6:**

By reason of the complexity of the cartographic image, the raster system does not allow radar images to be overlaid. The combined use of ARPA and ECDIS will make a great contribution to the safety of navigation. In the view of many mariners, this advantage, exclusive to ECDIS, would, alone, justify using this system of navigation.

**Functional characteristic 7:**

ECDIS allows the mariner to change the nominal scale for presentation of cartographic information. In particular, the scale can be enlarged (zoom) within limits compatible with the accuracy of the hydrographic data. This is a valuable advantage for navigation through narrow passages.

Wen the user of the raster system wishes to have a view of the whole of the chart he is using, he may reduce the scale in order to fit the chart into the size of the display. He will then have an overall picture that is not easy to read, with lettering and abbreviations becoming illegible. Although enlargement is technically possible, it is not envisaged by reputable manufacturers such as RACAL or KELVIN HUGHES, as the resolution of the image is fixed once and for all.

**Functional characteristic 8:**

The updating of ECDIS data is easy in principle, since cartographic objects are manipulated (e.g. move such-and-such a buoy from point A to point B). This is achieved by means of messages using few bits and may thus be transmitted by satellite.

In raster mode, only an "update of the drawing" can be made. Thus entire "tiles"[5] of the chart are re-drawn; the number of these depends on the extent of re-drawing required. Any area affected is entirely re-drawn, including what has not changed. A correction as simple as the moving of a buoy and its legend implies a good number of "tiles" and requires numerous bits. By reason of the volume of data updated, the dispatch of a disk rather than transmission by satellite is provided for. But with both systems the correction procedure is entirely automatic. Which is an appreciable common advantage particularly sought after by shipping companies.

### Disadvantages specific to the raster system

As the raster system is based on re-copying the chart, the notes, the warnings, and information concerning currents and tides, are only accessible for the mariner if they enter into the field of the display, taking account of the ship's position. Thus, when a reference to a warning appears on the display, it is unlikely that the text of the warning itself will be displayed at the same time. To have access to the text, the mariner will have to use the corresponding paper chart, since seeking the text with the raster system supposes a reduction in scale to permit the whole chart to be displayed, but making it impossible to read! With ECDIS it suffices to click onto the position of the reference to the warning to display the relevant text, either in the margin of the screen or on an auxiliary display.

The raster system is, for the same reasons, ill-adapted to the complete preparation of a voyage. The mariner will inevitably use the paper chart, even if he ends by tracing the planned route on the raster system.

## CONCLUSION

It therefore appears that the raster system is far from offering the variety of services that ECDIS can render. It is true that the ECDIS prototypes do not give - for the moment - much more nautical information than is available on charts (5). But the conception of ECDIS and the properties of vector data permit all the extentions indicated (Functional characteristics 2 and 3). The raster system is not able to provide information other than that which appears on the chart. Its rigidity is an insurmountable obstacle to any development and notably to the overlaying of a radar image.

To simplify, we may say that the raster system has two advantages compared with the paper chart: it avoids plotting the ship's position on the chart manually, and updating of the raster chart is automatic. As we have seen, it is always necessary to refer to the normal paper chart. Carrying such a chart is also compulsory under relevant regulations, which only dispense mariners who have ECDIS at their disposal from the obligatory carrying of paper charts.

[5] The "tile" will be, for example, an area of 5mm x 5mm on the chart.

Created as a result of difficulties and delays in the process of putting ECDIS into operation, and in particular the shortage of vector data for the principal shipping routes, raster systems are substitutes. These systems have the advantage of already having at their disposal data covering vast areas used for navigation. The pragmatism which led to their use well illustrates the French proverb: "Faute de grives on mange des merles" ("If thrushes are not available, we make do with blackbirds.") This temporary situation must not cause us to lose sight of the fact that decisive progress in navigation will only be achieved through ECDIS. The efforts in hand to achieve this purpose must be pursued and even speeded up.

May we envisage that raster systems will disappear when an extensive data base for ECDIS is available? I do not think so, because, for many years to come, certain areas will remain beyond those covered by the data base constituted for ECDIS. In order to navigate in such areas, either the paper chart alone or a raster system will be used. This "stand-in" can hope, therefore, despite its limitations, to enjoy quite a considerable life-span.

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