CHAPTER 14

ECDIS AND THE INTEGRATED BRIDGE

INTRODUCTION

1400. Operating Concept

Bridge watch officers have three main duties:

Navigation

- Watch officers process navigation information from several different sources. They take fix positions from satellite and hyperbolic receivers. They measure bearing lines and radar ranges to suitable NAVAIDS. They then plot this information on a paper chart.

- After plotting the information on a chart, watch officers evaluate the navigation picture. They determine if the ship's present position is a safe one. They project the ship's position ahead and plan for future contingencies. The evaluation step is the most important step in the navigation process. Properly executing this step is a function of the watch officer's skill and how well the ship's actual navigation situation is represented on the chart. That representation, in turn, is a function of both plotter and sensor accuracy.

Collision Avoidance

- Watch officers evaluate the contact situation and calculate the closest points of approach (CPA's) for various contacts.

- Watch officers maneuver in accordance with the Rules of the Road to avoid close CPA's and collisions.

Ship Management

- Watch officers conduct evolutions that are part of an individual ship's routine.

The integrated bridge is designed to reduce the time spent on navigation by eliminating manual data processing and providing the navigator with a display which aids him in quickly evaluating the navigation picture.

Preliminary studies seem to indicate that time spent on navigation as a percentage of total watch officer duties drops significantly when using the integrated bridge. This does not necessarily lower the overall watch officer workload, but it does increase the percentage of time he can devote to ship management and collision avoidance.

THE INTEGRATED BRIDGE

1401. System Components

The term "integrated bridge" encompasses several possible combinations of equipment and software designed specifically for each individual vessel's needs. Therefore, each integrated bridge system is different. This section introduces, in general terms, the major equipment likely to be found in an integrated bridge system.

• **Computer Processor and Network:** This subsystem controls the processing of information from the ship's navigation sensors and the flow of information between various system components. It takes inputs from the vessel's navigation sensors. Electronic positioning information, contact information from radar, and gyro compass outputs, for example, can be integrated with the electronic chart to present the complete navigation and tactical picture to the conning officer. The system's computer network processes the positioning information and controls the integrated bridge system's display and control functions.

• **Chart Data Base:** At the heart of any integrated bridge system lies an electronic chart. An electronic chart system meeting International Maritime Organization (IMO) specifications for complying with chart carrying requirements is an **Electronic Chart Display and Information System (ECDIS)**. All other electronic charts are known as **Electronic Chart Systems (ECS)**. Following sections discuss the differences between these two types of electronic charts.

An integrated bridge system may receive electronic chart data from the system manufacturer or from the appropriate government agency. The mariner can also digitize an existing paper chart if the system manufacturer provides a digitizer. Electronic charts can differentiate between and display different types of data far better than conventional charts. Paper charts are usually limited to four colors, and they display all their data continuously. An electronic chart can display several colors, and it can display only the data the user needs. If the electronic chart is part of an ECDIS, however, it must always display the minmum data required by IMO/IHO. The database for a typical civilian 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.

• **System Display:** This unit displays the ship's position on an electronic chart and provides information on sensor status and ship's control systems. It displays heading data and ship's speed. It provides a station where the operator can input warning parameters such as minimum depth under the keel or maximum cross track error. It plots the ship's position and its position in relation to a predetermined track.

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.

• **Planning Station:** The navigator does his voyage planning at this station. He calculates great circle courses, planned tracks, and waypoints. The navigator digitizes his charts, if required, at this planning station.

• **Control System:** Some integrated bridges provide a system that automatically adjusts course and speed to follow a planned track. If the system is equipped with this feature, the navigation process is reduced to monitoring system response and providing operator action when required by either a changing tactical situation or a system casualty.

• **Radar:** Radar for navigation and collision avoidance is included in the integrated bridge. Since both the chart and the radar process their data digitally, data transfer between the two is possible. The "picture" from either one can be imposed on top of the picture of the other. This allows the navigator to see an integrated navigation and tactical display and to avoid both navigation hazards and interfering contacts.

ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM

The unqualified use of the electronic chart in the integrated bridge depends on the legal status of the electronic chart system in use. The IMO has defined the Electronic Chart Display and Information System as the integrated bridge system that complies with the up-to-date chart carrying requirements of international law. The Electronic Nautical Chart (ENC) is the ship's electronic chart data base used in an ECDIS system. The ENC is a subset of the Electronic Chart Database (ECDB), the digital chart database maintained by the national hydrographic authority.

ECDIS standards are still under development. This section will discuss some basic ECDIS design criteria.

1402. Digital Chart Data Formats

One question in the development of ECDIS has been whether the nautical chart should be digitized in **raster** or **vector** format.

Raster chart data is a digitized "picture" of a chart. 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 must be entered for every picture element (pixel) on the chart.

Vector chart data is organized into many separate files. It contains graphics programs to produce certain symbols, lines, area colors, and other chart elements. The programmer can change individual elements in the file and tag elements with additional data. 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.

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

1403. Digital Chart Data Transfer

The IMO, in its performance standards for ECDIS, has mandated that individual national hydrographic offices will supply official ENC data for ECDIS use. A preliminary data transfer standard, known as **DX 90**, has been proposed within the IHO; IHO is debating the utility of this standard. Regardless of the transfer standard recommended, each national hydrographic office that produces a data base will decide what transfer standard it will use.

To ensure the reliability of the data, the ECDIS must not allow data from an unofficial source to erase, overwrite, or modify HO supplied data.

1404. ECDIS Warnings And Alarms

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. IMO standards require that certain alarms be available on the ECDIS. Among these are:

1. Deviating from a planned route.
2. Chart on a different geodetic datum from the positioning system.
3. Approach to waypoints and other critical points.
4. Exceeding cross-track limits.
5. Chart data displayed overscale (larger scale than originally digitized).
6. Larger scale chart available.
7. Failure of the positioning system.
8. Vessel crossing safety contour.
9. System malfunction or failure.

Alarms consist of audible and visible warnings. The navigator may determine some setpoints. For example, he may designate a safety depth contour or set a maximum allowed cross-track error. Operational details vary from one system to another, but all ECDIS will have the basic alarm capabilities noted. The navigator is responsible for becoming familiar with the system aboard his own ship and using it effectively.

1405. 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 udata 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.

1406. ECDIS 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.

1407. ECDIS Calculation Requirements

As a minimum, an ECDIS system must be able to perform the following calculations:

- Geographical coordinates to display coordinates, and display coordinates to geographical coordinates.
- Transformation from local datum to WGS-84.
- True distance and azimuth between two geographical positions.

• Geographic position from a known position given distance and azimuth.

• Projection calculations such as great circle and rhumb line courses and distances.

ELECTRONIC CHART SYSTEMS

1408. ECS And ECDIS

Electronic Chart Systems (ECS) are those digital chart display systems that do not meet the IMO requirements for ECDIS. Until an ECDIS standard is approved and a particular ECS meets that standard, no ECS can be classified as an ECDIS. The practical consequence of this distinction is that an ECS cannot be used to replace a paper chart.

Legal requirements notwithstanding, several companies are producing very sophisticated integrated bridge systems based on electronic chart systems. These integrated bridges combine accurate electronic positioning sensors with electronic chart presentations to produce a video representation of a chart which displays and updates the ship's charted position at frequent intervals. Electronic charts can also display tracklines, cross-track error, and other operational data. These systems have the potential to integrate radar systems and control systems to create a fully integrated bridge.

The uncertainty surrounding the final ECDIS standard has not lessened the marine community's demand to exploit the potential of this revolutionary technology.

One consequence of this demand has been that some national hydrographic offices are producing official digital raster charts for use in electronic charting systems. In addition, a number of commercial companies have been licensed to digitize the paper charts of various national hydrographic offices. However, these are not the data bases envisioned by the IMO standard.

Remember that ECDIS is a *system*. The electronic chart data base is only a subset of this system. Therefore, even though electronic charts come from a national hydrographic office or from official charts, the integrated bridge system in which the chart is used may not meet the ECDIS *system* requirements.

NAVIGATION SENSOR SYSTEM INTERFACE (NAVSSI)

1409. System Description

DMA's Vector Product Format (VPF) Digital Nautical Charts (DNC's) are used in conjunction with the Navy's version of the integrated bridge: the **Navigation Sensor System Interface (NAVSSI)**. NAVSSI is being developed to fulfill three important functions:

- Navigation Safety: NAVSSI distributes real time navigation data to the navigation team members to ensure navigation safety.
- Weapons System Support: NAVSSI provides guidance initialization for use by weapons systems.
- Battlegroup Planning: NAVSSI provides a worksation for battlegroup planning.

The navigation function of NAVSSI, therefore, is only one of several functions accomplished by the system. The navigational portion of NAVSSI is being designed to comply with the IMO/IHO ECDIS standards for content and function.

The heart of NAVSSI is the Real Time Subsystem (RTS). The RTS receives, processes and distributes navigational data to the navigation display, weapons systems, and other networked vessels. This ensures that all elements of a battle group have the same navigational picture. Inputs come from GPS, Loran, inertial navigation systems, gyrocompass, and speed log. The bridge display consists of a monitor and control panel, while the RTS is mounted below decks. ENC's are contained in the **Display and Control Subsystem (DCS)** typically mounted in the chartroom with a monitor on the bridge. This is unlike many current commercial systems which have all hardware and software in a single unit on the bridge. A separate NAVSSI software package supports operator interface, waypoint capability, collision and grounding avoidance features, and other aspects of an ECDIS.

Figure 1410 illustrates a basic block diagram of the NAVSSI system. The RTS takes inputs from the inertial navigators (WSN-5's), the GPS PPS (WRN-6), the gyro compass, the EM Log, and the SRN-25. The SRN-25 outputs GPS SPS, Transit SATNAV, and Omega positions. The RTS distributes navigation information to the various tactical applications requiring navigation input, and it communicates via a fiber optic network with the DCS. The DCS exchanges information with the Navigator's Workstation.

1410. The Digital Nautical Chart

NAVSSI uses the **Digital Nautical Chart (DNC)** as its chart database. The DNC is in Vector Product Format and is based on the contents of the traditional paper harbor, approach, and coastal charts produced by DMA and NOS.

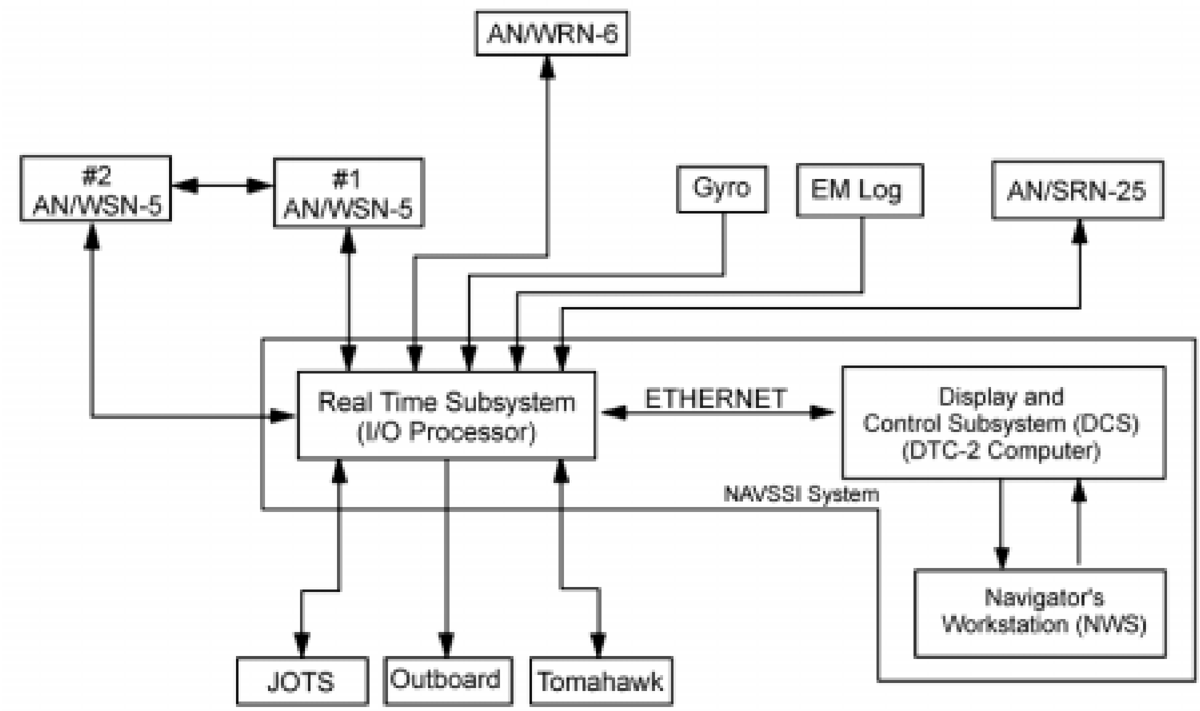

Figure 1410. Block diagram of NAVSSI.

Horizontal datum is WGS 84 (NAD 83 in the U. S. is equivalent). There are three vertical datums. Topographic features are referenced to Mean Sea Level, and the shore line is referenced to Mean High Water. Hydrography is referenced to a low water level suitable for the region. All measurements are metric.

DNC data is layered together into 12 related feature classes:

- Cultural Landmarks
- Earth Cover
- Inland Waterways
- Relief
- Landcover
- Port Facilities
- Aids to Navigation
- Obstructions
- Hydrography
- Environment
- Maritime Limiting Lines (channels, demarcation lines, anchorages, etc.)
- Data Quality

Content is generally the same as on a paper chart. The data is stored in **libraries**; each library represents a different level of detail. The libraries are then stored on CD-ROM and organized as tiles according to the **World Geodetic Reference System (GEOREF)** tiling scheme. Tile sizes are 15' X 15' for harbor charts, 30' X 30' for approach charts, and 3° X 3° for general charts. The data now contained on as many as 4000 conventional charts will eventually be contained on as few as 30 CD's.

1411. Correcting The Digital Nautical Chart

There are currently three proposed methods for correcting the DNC data base: Interactive Entry, Semi-Automatic Entry, and Fully Automatic Entry.

Interactive Entry: This method requires the interactive application of the textual Notice to Mariners. The operator determines the corrections from the Notice. Then, using a toolkit, he selects the symbol appropriate to the correction required, identifies the location of the symbol, and adds the appropriate textual information identifying the nature of the correction. This method of correction is labor intensive and subject to operator error. It also clutters the screen display because it can be applied only as an overlay to the ENC data.

Semi-Automatic Entry: This method requires the operator to enter the correction data furnished in correct digital format by the originating hydrographic office into the system via electronic medium (a modem or floppy disc, for example). The ECDIS then processes these corrections automatically and displays an updated chart with the changed data indistinguishable from the remaining original data base.

Fully Automatic Entry: The fully automatic method of correction entry allows for a direct telecommunications link to receive the official digital update and input it into the ECDIS. This process is completely independent of any operator interface. Internal ECDIS processing is the same as that for semi-automatic updating of the data base.

CONCLUSION

The emergence of extremely accurate electronic positioning systems coupled with the technology to produce an electronic chart is effecting a revolution in navigation. When fully mature, this technology will replace the paper charts and plotting instruments used by navigators since the beginning of sea exploration. There are several hurdles to overcome in the process of full replacement of paper charts, some legal, some bureaucratic, and some technical. Until those hurdles are overcome, electronic charting will be in a transitional state, useful as a backup to traditional techniques, but insufficient to replace them. How this transition period will play out and the final form of the internationally recognized ECDIS system are subjects for the next edition of *The American Practical Navigator*.