1 An Imaginary Voyage with an Electronic Chart

1.1 Using ECDIS

A paper chart on a chart table, a set of parallel rulers and a set of compass dividers – these are time-tested and widely-used tools for shipboard navigation. But now, in the information age, these traditional tools have a competitor – an electronic chart system that displays navigational charts on a computer screen. More than a computer graphics display, the 'electronic chart' is a real-time navigation system that will eventually replace the need for ships to carry paper nautical charts. Electronic chart systems introduce a new level of performance into navigation and are leading to major changes in maritime navigation.

It should be pointed out early on that the term 'electronic chart' is rather narrow and can be somewhat misleading. It does not express the real potential or capability of this new system. An electronic chart system is much more than a simple device to reproduce a conventional paper nautical chart on the screen. As a completely new and interactive navigation information system, it has the potential for displaying all necessary chart and navigation-related information required for the safe operation of a vessel.

Figure 1.1: Modern bridge with an electronic chart system.

The following hypothetical voyage of a ship equipped with a modern bridge (Figure 1.1) illustrates the use and value of an electronic chart system.

1.2 Starting situation

M/V 'ECDIS EXPRESS' (length 150 m, draught 7.9 m) – equipped with a type-approved ECDIS and official electronic chart data (ENC) – is coming in from the open sea. As the ship approaches the coast, it prepares to enter pilotage waters and later, an unfamiliar port. Not only is this the first time that the ship has ever entered this port, the fairway is difficult and there is heavy shipping traffic. In addition to being a dark winter afternoon, the weather is poor. There is a strong onshore wind and a heavy sea-state. Visibility is impaired by rain, and the radar display is affected by sea clutter. The time is 14:00 hrs. The ship's arrival into the port is planned for 20:30 hrs. To do this successfully, the ship must pass through a critical shallow water area between 17:30 hrs and 17:50 hrs. The Watch Officer on the bridge gives his full attention to the navigation task, including keeping a sharp lookout for other vessels. At the central 'conning station', alongside the radar console and other navigation and communication devices, is a high-resolution colour monitor serving as an electronic chart display (Figure 1.2). Using the electronic chart as an integrated navigation system, the Watch Officer is able to focus his attention on overall situational awareness without having to spend time running between the chart table, a position-fixing device, the radar and the AIS.

1.3 Record of the voyage

14:00 The monitor displays a **colour chart** image of the area showing the coastlines, safe and shallow water areas, aids-to-navigation (e.g. buoys) etc.. The contour line of 10 m, which is based on the current draught of the vessel, is clearly emphasised as own ship's '**Safety Contour**'. The electronic chart display is free from unnecessary and cluttering information (Figure 1.3). Only the information that the Watch Officer considers important is shown. For clarity, other information that is not necessary for the task-at-hand have been temporarily removed by him from the screen ('**Standard Display**' mode). As to the vessel's voyage, the electronic chart system shows the **Waypoints** and the **Planned Route** in the run-up to the coast. Own ship is represented by a small symbol. Its position (previously requiring laborious calculations before being plotted on the paper chart) is continually determined by a Global Positioning System (GPS) receiver, and automatically displayed. In '**Route Monitoring**' mode, the ship's symbol 'sails' across the electronic chart display in **Real-time** and in true motion – at its true-to-scale speed (18 kts). Periodically, the ship's position on the electronic chart is re-adjusted, and an adjacent charted area is displayed. All of this is done automatically. There is no need to change charts!

Figure 1.2: Watch Officer navigating with an electronic chart. Source: Sperry Marine (Northrop Grummon).

14:30 The vessel continues its approach to the destination port. The **Radar Image** is overlaid in green colour on the electronic chart display, and the radar image of the coastline closely matches that of the charted shoreline. This additional position confirmation provides increased confidence to the Watch Officer regarding the ship's position and way ahead for a safe transit. Currently, there are five radar targets on the chart display – each with vectors indicating direction and speed. The radar target on the starboard side is approaching on a collision course (CPA = 0.2 nm, TCPA = 5 min). The values are confirmed by the Automatic Identification System (AIS). The Watch Officer quickly recognises that the vessel will come dangerously close to own ship. As the burdened vessel, the Watch Officer performs the necessary collision avoidance manoeuvre. The electronic chart display clearly shows that the manoeuvre space is sufficient. The ship returns to its previous course.

15:00 As the ship nears the coast, it continues to use the automatic pilot for **Track Control**. The ship's Navigator closely monitors the track-keeping – including

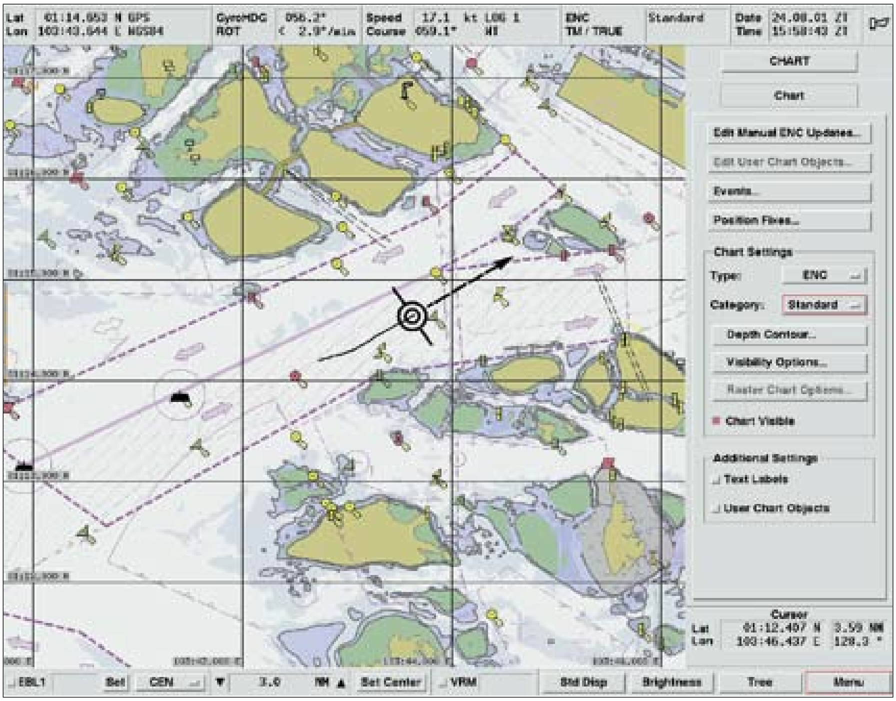

Figure 1.3: Electronic chart display showing all essential information for the task at hand. Sea area: Singapore. Source: SAM Electronics.

the planned radius of turn (0.5 nm) – on the electronic chart. With 5-10 m accuracy provided by the Differential GPS (DGPS) positioning system, any deviation from the planned route is quickly shown. Furthermore, the **Planned Track** and the radar image show a clear course ahead for this portion of the voyage. The Watch Officer compares the planned course (138°) with the one steered (139°). The next waypoint comes closer: 'Distance = 4.2 nm, Time-to-Go = 14 min'. The '**Look-ahead**' function (alarm time 10 minutes) is activated. There are no alarms or indications, and no apparent danger.

15:20 The ship now enters the **Traffic Separation Zone**. It is marked by several buoys and shown on the electronic chart as a '**Special area**'. The '**Pick Report**' indicates the new recommended course (152° inbound) in an **Information Window**. The radar echoes of the buoys match the charted positions on the electronic chart. However, there is one obvious exception: one of the buoys is apparently off-station. Using the electronic chart system, the Watch Officer makes a '**Mariner's Note**' ('Report buoy off-station') to report this to the Port Authority. The electronic chart display now shows the ship is passing a 'nun' buoy on the starboard beam. A quick glance from the bridge confirms this – no discrepancies between electronic chart and the real world.

15:40 As the ship nears the entrance to the port, a slower vessel is seen directly ahead in the narrowing fairway. Based on visual inspection, it appears that the vessel may obstruct the passage of own ship. However, the radar echo and the **ARPA Vector** on the electronic chart display indicate that the vessel is turning onto another fairway. No need to reduce speed and lose unnecessary time. The Captain now appears on the bridge.

15:45 As it becomes darker, the Watch Officer turns on the '**Half-light Display**' of the electronic chart. This is done so as to not affect the night vision of the bridge Watch Officers. Navigational lights with colour sectors (green; white; red) now appear on the electronic chart display.

15:50 The channel is near. The Navigator chooses the next larger '**Scale**' of the chart (corresponding to 4 nm **Range Scale**). The new display appears within a few seconds. A symbol of an (unknown) buoy is shown ahead of the ship. Using a **Cursor** to point on the object, the **Information Window** of the '**Pick Report**' opens to show details of a buoy (pilar shape; Fl(3) WRG 15 s 21 m 15 nm; 'radar-conspicuous'). Aha! No need to spend time paging through the 'Light List' to see which one it is.

16:00 The channel begins to narrow, vessel traffic increases, and the speed of the ship is reduced. With little warning, a vessel ahead – apparently trying to avoid a shallow area – veers threateningly close to MS 'ECDIS EXPRESS'. The Watch Officer quickly steers the ship as far as possible to starboard, all the while using the '**Safety Contour**' (previously set to 10 m) and '**Look-Ahead**' functions to verify that the ship will remain in safe water.

16:20 The Watch Officer displays the list of **Pilot Stations**, **Reporting Points** and **Radio Frequencies** on the screen. He then establishes radio contact (VHF channel 8) with the Pilot Station.

16:30 As the ship approaches the pilotage area, the Watch Officer increases the **Scale** of the electronic chart display again. The larger scale display shows that the ship is close to its planned route, and far enough from the nearest danger (a shoal water is 0.4 nm away). Another **Object** soon appears on the display – an underwater cable. Although useful, this information is not critical since the ship does not intend to anchor there.

16:35 During a quiet moment, the Watch Officer checks again to see if the vessel has the most recent '**Updates**' to the electronic chart. The last **Update via CD ROM** has been applied one week ago, the '**Permit for Chart Use**' has been validated via E-mail two months ago. Since this is the first time he has entered this port, he instructs the system to obtain the latest chart corrections via radio broadcast. Two update messages are automatically received and applied. The Watch Officer verifies on the screen that these electronic chart updates are from two days ago – a new buoy deployed a few days earlier and a new restricted area. Manual paper chart corrections are no longer necessary. With a sense of relief, the Watch Officer exclaims: 'This is a big time-saver, and we all know that time is money.'

16:40 The Pilot comes onboard. He carries his own portable electronic chart system. When asked why, his answer is convincing: he has entered numerous '**Pilot's Notes**' related to the particular situation in his pilotage area. Also, using a digital radio receiver, he automatically receives and displays the latest information from the Traffic Centre.

16:45 The ship nears a check point where a '**Mariner's Note**' has been entered into the electronic chart system during the '**Route Planning**': 'Pass before 16:50 hrs'. The Watch Officer is now certain that the ship can stay on schedule, and that it will be able to transit a shallow area ahead during the high tide window, and sail through safely with sufficient underkeel clearance. To be on the safe side, the Watch Officer displays all '**Spot Soundings**'.

16:52 The Watch Officer double-checks the position-fixing system. Since the own ship symbol does not blink to indicate a warning and since the position-fixing status bar indicates 'DGPS', he is confident that the ship is receiving the DGPS Broadcast Service. However, just to make certain, he displays more details about the position fixing system: '8 satellites visible, 6 satellites tracked, HDOP = 1.1'. The reference station is quite near and the DGPS Broadcast signal is strong. As such, he assesses that the **Position Accuracy** in this area is about 3 m. This is good enough for this type of transit.

17:04 The ship approaches the port. The ship's speed through the water is now 12 kts. However, the ECDIS indicates that there is an opposing **Tidal Current** of 3 kts making the speed over the ground only 9 kts. Using the '**Dynamic ETA Function**', the Watch Officer verifies that the shallow area will be reached at about 17:43 hours. The chart display is changed to a larger scale. Due to heavy sea clutter, the radar echoes of the buoys are difficult to see. However, using the electronic chart system they can be clearly identified. The Mate remarks to the Master: 'It's impossible to see the buoys using only radar.' Following a change to manual steering, the Watch Officer keeps an eye on the ship's track by comparing the planned route with the actual position. Even the smallest **Deviation from the Planned Track** is quickly (real-time) shown on the electronic chart.

17:35 The visibility improves, somewhat. Although there is no indication that there is a 'Loss of DGPS', the Captain orders a 'conventional' visual and radar position check. Not too far ahead there is an **Underwater Obstruction** near the fairway. A three-point visual fix and the bearing and distance from a radar echo of a nearby lighthouse are obtained, the position is plotted on the display by the electronic '**Line of Position**' (**LOP**) function. There is very close agreement with the DGPS position. The distance the vessel will be from the underwater obstacle is sufficiently large. There is no apparent danger.

17:45 So far, the time-schedule is being kept. Suddenly, the ship's '**Safety Contour**' alarm sounds. The depth sounder shows only 1.8 m of water under the keel and the alarm was set for 2.0 m. However, this depth was predicted by the electronic chart system. Although the vessel can safely transit at 12 kts with a 1.0 m under-keel clearance, the vessel slows to avoid any 'squat' when transiting through this critical area. Water depth under the keel begins to increase. The voyage continues. All seems OK.

19:35 Trust is good, but checking is better. It appears that the '**Own Ship Symbol**' on the chart has come into the **Red Sector of a Lead Light**. A quick look through the bridge window confirms this. It is now time for a course correction.

20:20 The ship nears the entrance to the harbour (Figure 1.4). The fog becomes more dense, and visibility is now less than 100 m. The chart display is

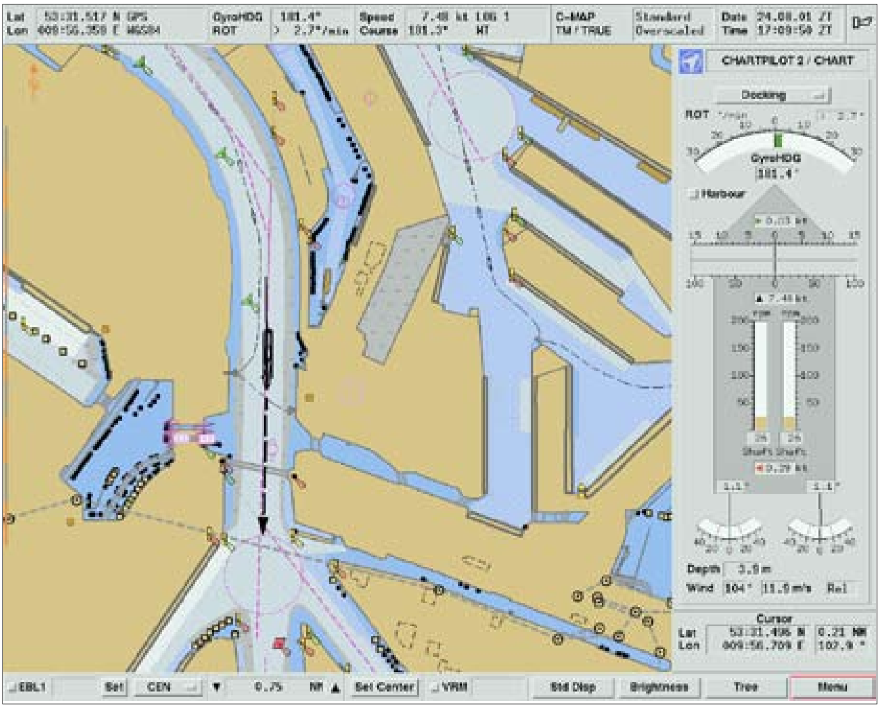

Figure 1.4: Using the electronic chart in confined waterways. Sea area: Port of Hamburg. Source: SAM Electronics.

changed to the **Largest Scale** available (1:5000) without '**Over-Scale Status**'. All the necessary details, the port entrance, the individual quays, and the planned route to the ship's berth are shown. Additional information (speed and direction of wind and current) is displayed in a separate window. The Watch Officer looks once more at the **Planned** and **Past track**. He states to the Captain that the ship is ready to enter the harbour.

20:30 Before coming alongside, the ship must turn 180° in order to berth 'stern to.' A difficult manoeuvre to perform in tight confines with good visibility, there is some risk in this type of operation. The own ship is now displayed on the screen ('**Usage Berthing**') as a '**True-to-scale**' symbol that shows the ship's length (150 m) and beam, as well as the actual position and heading in 'real-time.' In the '**Prediction Mode**' (prediction time 2 minutes), the Watch Officer closely follows the distance readings from the ship's port side to the quay, and from its stern to the intended tie-up position. Without having to leave his workstation, he issues the necessary commands to the helmsman for steering and engine control. On the electronic chart display, he monitors the vessel's manoeuvre in a confined waterway without viewing either the bow or stern. 'The larger the scale, the more valuable is the electronic chart' (Figure 1.4). In addition, a high-accuracy DGPS with two antennas (fore and aft) and a radar overlay (even if disturbed by land object shadows and short distance effects) provide assistance for manoeuvring.

20:38 The ship is now alongside the pier. Safe, and on time.

1.4 Summary

This imaginary voyage describes both the potential and the complexity of an electronic chart system. The essential elements of this new type of shipborne navigation system are the automatic and continuous display of a ship's position on the chart, and the immediate availability of the information applicable to a given situation. Using an electronic chart system, a voyage is not only safe, but also efficient. It can also be more economical since it helps to avoid unnecessary and costly delays.

The electronic chart system should also be seen as a decision support system that contains in its memory other important navigational information. Previously, this information was available on paper charts or from various navigational publications (e.g. Light List, Coast Pilot, etc.). In the simplest sense, an electronic chart system answers the following basic questions:

- What is own ship's position?
- Where are charted obstacles and hazards to be avoided?
- Where are other vessels?
- What are the present or anticipated environmental conditions?
- Are there any dangers along the planned route?