6.9 Bridge equipment tests

Ships requesting class notation W1-OC or W1 must comply with rules for equipment tests. After installation of equipment, on-board testing shall be performed in order to ascertain that the equipment, as installed, operates satisfactorily.

It should be noted that reliable figures for all aspects of equipment performance/accuracy cannot be established by the on-board testing required for classification. Hence, to ensure that equipment performance is in accordance with specifications, shipowners are advised to choose equipment that is type approved.

A detailed test programme for the on-board testing of equipment should be submitted for approval at the earliest possible stage before sea trials. The following systems are tested according to general requirements for testing of equipment:

- gyrocompass
- automatic steering system
- rudder indicator(s)
- rate-of-turn indicator
- speed log
- echo sounder
- radar system
- ARPA system
- electronic position fixing systems
- watch monitoring and alarm transfer system
- internal communication systems
- nautical communication system
- sound reception system
- computer system(s)
- Electronic Chart Display and Information System (ECDIS)
- Automatic Navigation and Track-keeping System (ANTS)
- conning display.

6.10 Examples of integrated bridge systems

A variety of manufacturers offer a range of integrated bridge systems that can be tailored to fit the requirements of the user. Some of these systems will be described in this section. The systems selected come from leading manufacturers in this field.

6.10.1 Voyager by Furuno Electric Co. Ltd

An automatic navigation system designed by Furuno to meet the requirements for one-man bridge operation and the new ECDIS standards is the Voyager Integrated Bridge System. The system was designed to meet the class notation W1-OC of DNV, Norway. The system is modular which allows it to be set up to meet the requirements of the user and to provide capability for future expansion of the system as necessary. The complete system requirement comes from a single supplier with the claimed benefits of:

- increased safety
- increased cost-effectiveness
- increased navigation efficiency.

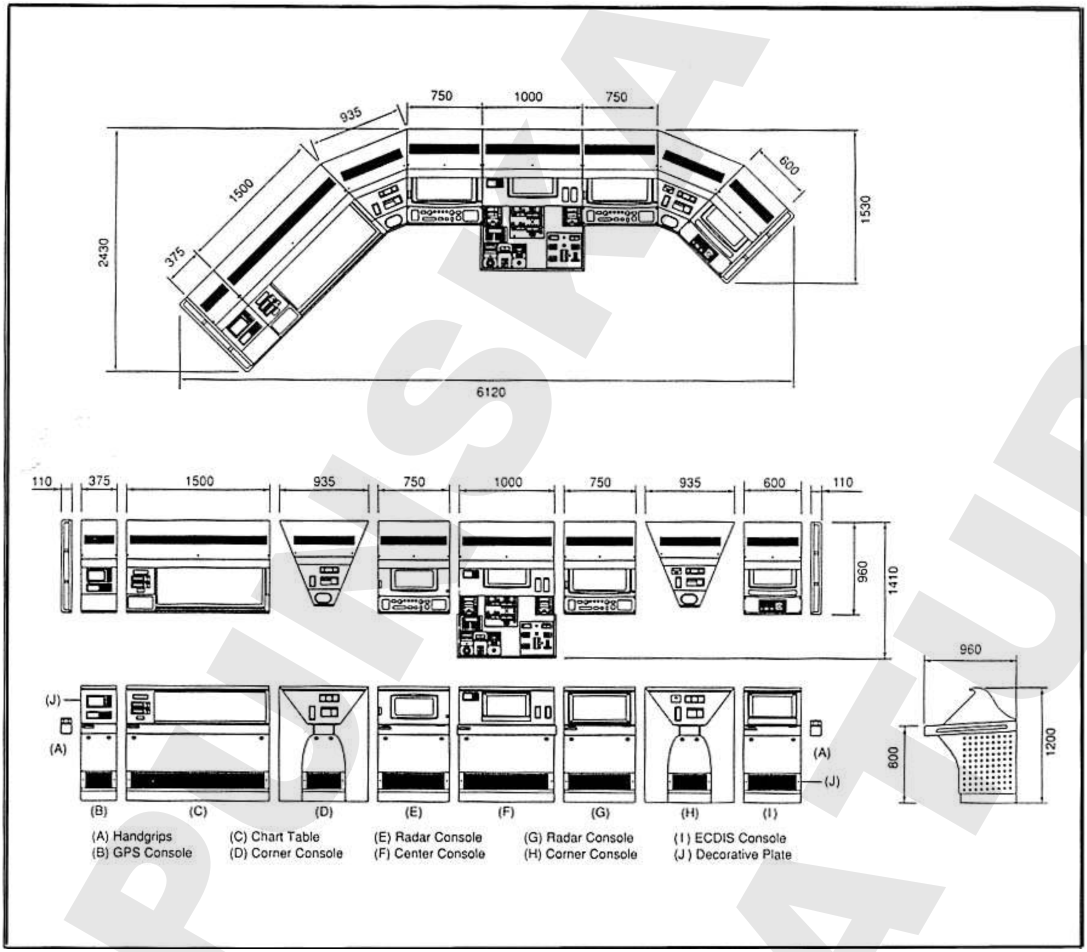


Figure 6.2 Components of the Voyager integrated bridge system. (Reproduced courtesy of Furuno Electric Co. Ltd.)

The modular nature of the system components can be seen from Figure 6.2 which shows a possible bridge layout using the Voyager system. Figure 6.3 shows one module, that of the ARPA/Radar which is module E/G in Figure 6.2.

Main functions of Voyager

There are three main functions of the system:

- electronic chart display and user interface
- position calculation and track steering
- automatic steering of the vessel.

Each of the main functions is performed using an individual processor as indicated in Figure 6.4. This guarantees real time data processing for critical applications such as positioning and steering.

Figure 6.3 Voyager ARPA console. (Reproduced courtesy of Furuno Electric Co. Ltd.)

The system has built-in dual displays to satisfy the requirement for separate ECDIS and conning monitors. The ECDIS monitor provides the main display and user interface for the navigation system, while the conning monitors display the most important navigational sensor data in a graphical form, i.e. gyrocompass, speed log etc.

The navigation system is operated through a control panel that has dedicated function and execute keys for fast, easy operation. The steering functions are performed on their own operation control panel that integrates all functions for automatic steering. A block diagram that shows these control panels and also indicates all inputs to the navigation and track-keeping processor is shown in Figure 6.5. Figure 6.5 also indicates the type of interface connection that exists between a particular sensor and the processor.

Electronic chart display and user interface

For this system the electronic chart functions are designed to meet the performance standards for the ECDIS as laid down by the IMO and the IHO. More details on these requirements can be found in

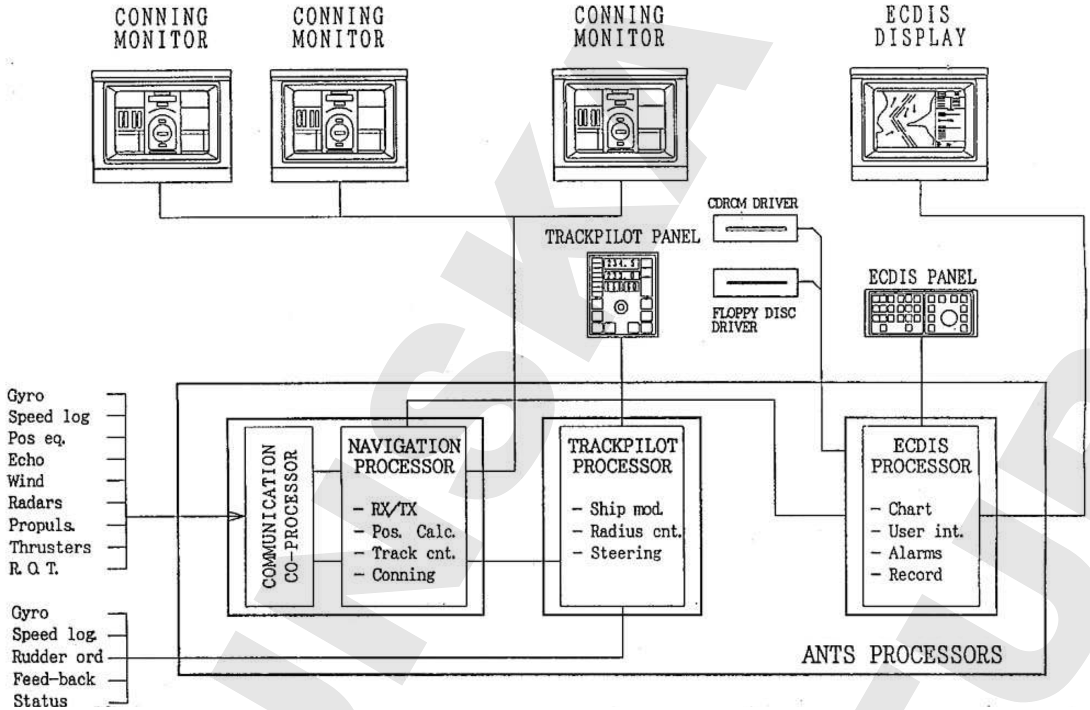


Figure 6.4 Block diagram of the Voyager integrated bridge system. (Reproduced courtesy of Furuno Electric Co. Ltd.)

Chapter 7. ECDIS functions are performed on their own computer unit, housed in the same electronic cabinet, so as to optimize graphical performance and cost, especially when a second chart display is necessary.

The main features of the ECDIS are:

- presentation of an electronic version of a sea chart, based on the latest ENC format using a 21- (or 29-) inch high resolution colour display
- multiple navaid interface for GPS/DGPS, gyrocompass, speed log, echo-sounder etc.
- capable of use with both ENC and ARCS
- route planning and route monitoring
- primary and secondary route planning facilities
- grounding warnings
- user generated navigational safety lines which are overlaid on the radar screen
- user selectable chart layer presentation
- navigational tools such as VRM, EBL, track-ball
- display of ARPA targets
- voyage recording to meet standards
- user generated information note-books
- display of alarms
- MOB and event functions
- dedicated function keys for scale up/down, standard display, TM-reset and other functions which are the most often used functions.

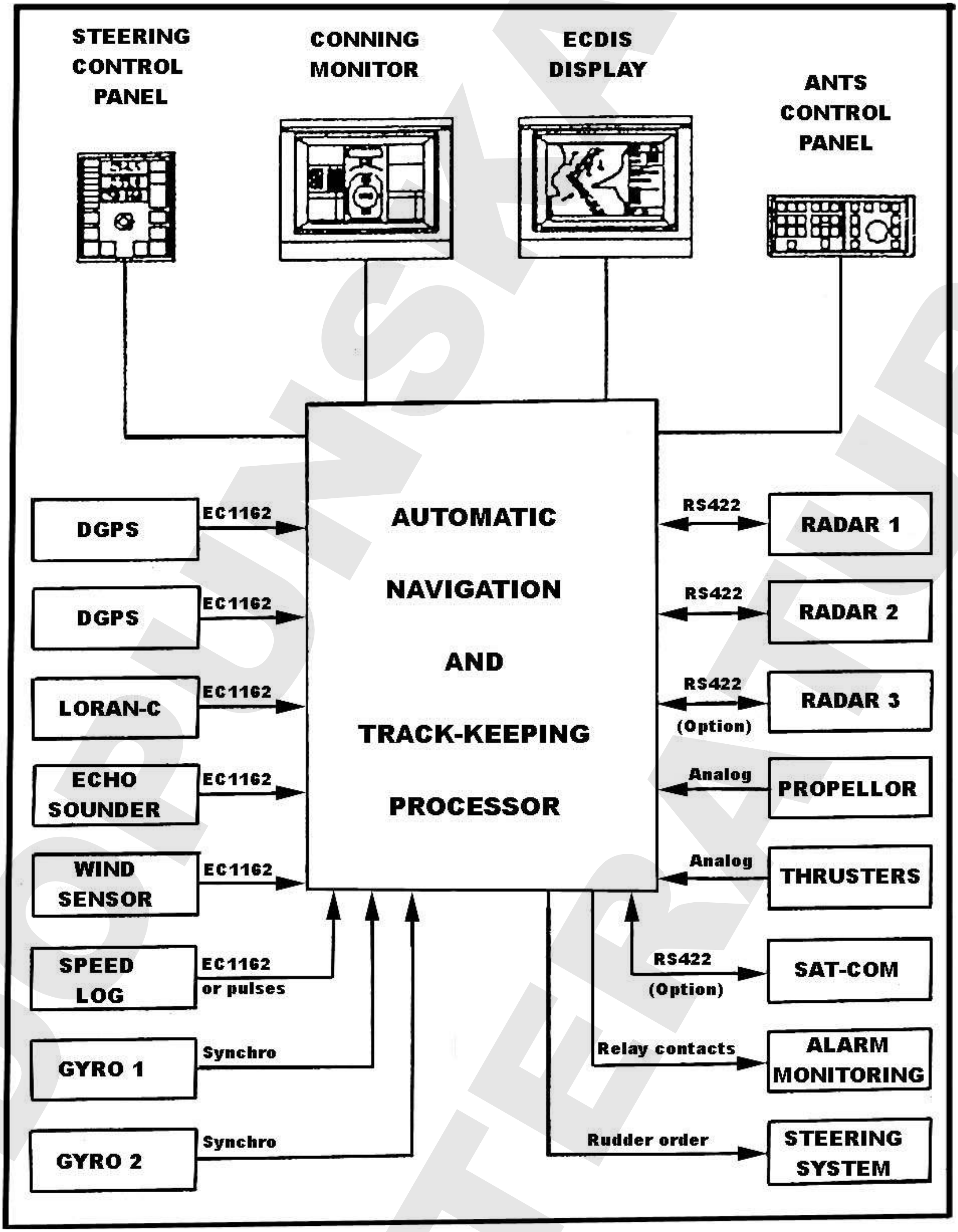


Figure 6.5 Block diagram of Voyager automatic navigation and track-keeping system (ANTS). (Reproduced courtesy of Furuno Electric Co. Ltd.)

The option of fitting a second ECDIS computer and display, to meet the required back-up arrangements in case of an ECDIS failure, is available. If fitted, the second ECDIS computer is linked to the first through a local area network (LAN).

Position calculation and track steering

The ship's position is calculated from the position sensors using the information from the gyrocompass and speed log. The position calculation is based on Kalman filter technology, which is capable of using different types of sensors and in operator-defined configurations.

Because of the need to allow for time-critical operations in position calculation and track steering, a separate processor is used for these functions. The main features of this processor are:

- interface to all external devices
- position calculation based on Kalman filter technology
- position quality calculation and alarm
- off-track calculation and alarm
- waypoint pre-warning and waypoint alarm
- graphical process and display for conning information.

Automatic steering function

The system includes a complete radius/track controlled autopilot for safe and automatic steering of the vessel with the functions and operations meeting the DNV-W1 requirements. The autopilot is fully integrated into the system allowing it to be easily controlled and operated.
The main features of the automatic steering system are:

- speed adaptive operation
- radius controlled turns
- direct gyro and log inputs for accurate and reliable performance
- user selectable steering modes
- gyro mode (rudder limit controlled)
- radius mode (immediate course change)
- programmed radius mode (programmed course change)
- programmed track mode (position referenced course change)
- precision track steering with pre-memorized waypoints
- relaxed track steering with pre-memorized waypoints.

The autopilot system has its own operation control panel for logical, simple to use operation while two separate operation control panels can be installed for special applications.

Interface specifications

The Voyager has a wide and flexible interface structure that allows for the system to be easily set up and configured for use. Both analogue and serial digital interfaces are available. The available interfaces to other systems are:

- gyrocompass: one analogue and one serial (NMEA) or two serial (NMEA)
- rate-of-turn gyro: analogue or serial (NMEA)
- speed log: pulse type or serial (NMEA)

- position receivers: up to five serial inputs (NMEA)
- echo sounder: serial input (NMEA)
- wind sensor: serial input (NMEA)
- rudder angle: analogue or serial (NMEA)
- propeller RPM/pitch: analogue or serial (NMEA)
- thrusters: up to four analogue inputs.

The autopilot interface requirements are:

- gyrocompass: two 1:1 synchros or high update rate serial inputs (NMEA)
- speed log: 200 p/nautical miles pulses or serial input (NMEA)
- rudder order: analogue output (0.25 V/degree) or solid-state solenoid outputs
- steering status: galvanically isolated contacts.

If a direct solenoid type of steering order is required then an optional feedback unit and solenoid drive distribution box is required.

Electrical specifications

The following supplies are required with battery back-up in case of supply failure:

navigation system	24 V d.c. supply (250 W approx.)
alarm supply	24 V d.c. supply (10 W approx.)
display monitors	230 V a.c. or 110 V a.c.

6.10.2 NINAS 9000 by Kelvin Hughes

Kelvin Hughes, the Naval and Marine division of Smiths Industries Aerospace, offer a fully integrated navigation system. Units from the Kelvin Hughes Nucleus Integrated Navigation System (NINAS) are used together with ancillary navigational equipment from specialist manufacturers.

The advantages claimed for the NINAS 9000 system include the following.

- Any number of auxiliary consoles can be added to the basic radar and navigation displays
- The use of modules gives flexibility in the final arrangement adopted by the ship owner and ship operator
- The centre consoles can be adapted to accept equipment from a number of Kelvin Hughes preferred third party suppliers
- The system is based around the proven nucleus2 6000 radar systems which are available with a variety of antennas and transmitters.

A possible bridge layout for a large passenger-carrying vessel is shown in Figure 6.6.

The wheelhouse layout consists of a centre-line steering console, two mid-position (manoeuvring and pilot) and two enclosed bridge wing consoles. The manoeuvring and pilot stations consist of a dedicated radar and a dedicated ECDIS/conning display, both being type approved CRT equipment. The centre-line station has two multifunctional LCD displays, which connect to any of three radar processors, for use as a remote operating station for either of the two ECDIS displays or as a remote operating station for any other function as required. The two stations at each wing bridge perform a similar function to that of the centre-line station.

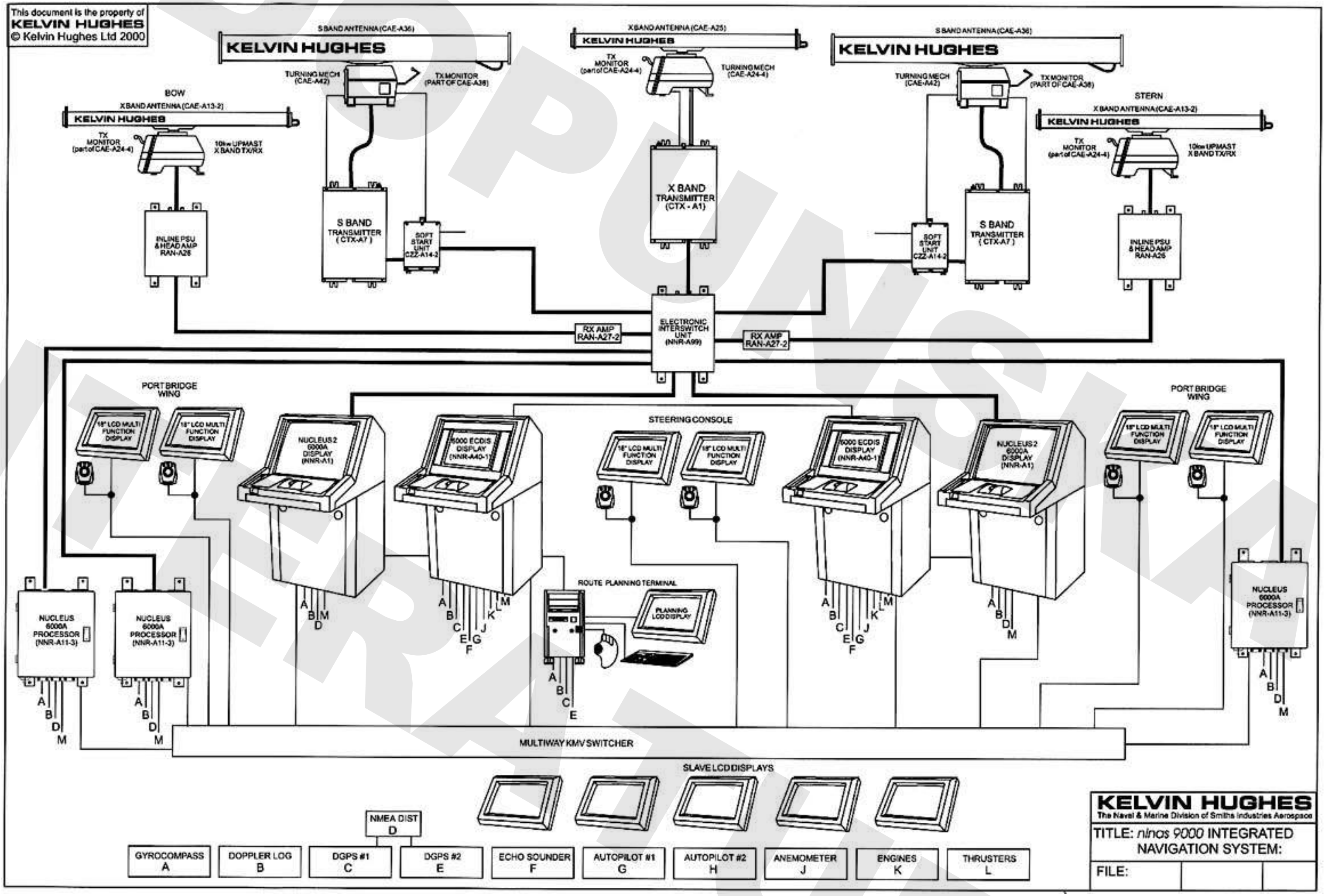


Figure 6.6 NINAS 9000 integrated bridge system. (Reproduced courtesy of Kelvin Hughes.)

Display systems

1 Radar displays

The two radar displays are 26-inch PPI, rasterscan ARPA radar displays with 10 range scales 0.25–96 nautical miles presented in relative motion, true motion and centred display true motion. There is auto tracking capability for up to 50 targets with a choice of manual or auto acquisition of targets using guard zones or footprint acquisition. The display has as standard parallel index lines, a flexible mapping system with a map storage capacity of 64K byte showing, for example, 100 maps of 80 elements.

The display has an interfacing capability of two RS232 bi-directional serial links and four NMEA opto-isolated inputs. The input capabilities are:

- GPS/Loran; waypoints; route; chart ‘puck’ position
- steering sequence; man overboard position; turning radius data
- serial link data from navigation display.

Output capabilities are tracker ball position and target data to ECDIS. A tracker ball and three buttons control all the radar display functions with external tracker-ball capability from each bridge wing.

2 ECDIS displays

The two ECDIS displays are IEC 1174 type approved 20-inch displays with the following functions.

- Operates with Windows-NT operating software with multi-window display showing S57 ed.3 ENC vector charts and/or ARCS/NOAA (BSB) raster charts. These may be viewed simultaneously or independently in variably sized windows.
- Graphic overlay of ownship symbol, route, waypoints, target vectors and trails on chart.
- Radar interlay of radar target echoes on chart. The interlay technique places the radar information video plane below that of the overlay to avoid obstruction of essential information.
- The ECDIS display can also act as a slave radar display by having its own radar video processing functions that allow independent control of the radar image on the ECDIS.
- North-up, course-up and head-up ENC chart presentation.
- Route safety zone function which provides a three-dimensional guard zone around own ship to monitor ship draft against chart depths and ships air draft against chart clearances to improve safety when on passage or route planning.
- Automatic plotting of time on chart with plot-on-demand function for special events.
- Passage calculator that allows route planning from the ECDIS screen. This allows calculation of distances, ETA, required speed for specific ETA and other navigational computations. This may be carried out locally or at a networked optional route planning workstation.
- Planning may be carried out visually with waypoints being dragged to modify legs and to allow the route to pass around obstacles.
- Uses ENC chart embedded database for interrogation feature, which allows the operator to request pop-up window information for any buoy, light etc. Also menu selection allows ECDIS or traditional chart symbols to be viewed for buoys and lights. There are six ENC colour palettes for optimal viewing in all light conditions.
- Continuous display of own ship heading, speed, position and depth on right side of the screen.
- Automatic Navigation and Tracking System (ANTS) interface to autopilot, allowing automated route sailing and constant radius turns.
- ECDIS display may be controlled either from the local tracker ball and three-button screen control unit (SCU) or from the remote display.

Additional functions within the ECDIS systems include a conning display, featuring the display of real-time vessel's position upon the chart in use, while displaying navigational and dynamic data in side panels. Data displayed includes:

- position
- heading
- speed (dual axis)
- depth
- wind (true and relative)
- route data
- engine RPM
- engines and thrusters.

3 Centre line console multi-function displays
Two 20-inch LCD displays that are capable of operating in the following modes.

- Fully independent radar displays capable of controlling any one of the five main radar transmitters.
- Remote radar displays capable of controlling any one of four main radar transmitters via another display (in the event of failure of the unit's own processor).
- Remote ECDIS/Conning display.

Additional functions that could also be allowed include:

- CCTV
- control and command monitoring
- alarm monitoring.

4 Bridge wing multi-function displays
Two 18-inch LCD displays that are capable of operating in the following modes.

- Fully independent radar displays capable of controlling any one of the five main radar transmitters.
- Remote radar displays capable of controlling any one of four main radar transmitters via another display (in the event of failure of the unit's own processor).
- Remote ECDIS/conning display.

Additional functions that could also be allowed include:

- CCTV
- control and command monitoring
- alarm monitoring.

5 Route planning terminal
A 17-inch LCD display with a dedicated processor designed in the same manner as an IEC 1174 type approved ECDIS display. The route planning terminal is installed as a slave unit to allow off-line route planning at the chart table position. The unit includes dedicated interfaces to log, gyro and GPS to allow it to act as a back-up ECDIS in the event of failure of the main units. Features are as for the type approved ECDIS, with the exception of radar interlay and target data.

Other components of the total system include the following.

- *Radar transmission system*. This comprises a five-way interswitched X and S band system allowing independent control of individual systems and complete interswitching of all radars.
- *Autopilot and steering system*. A system with full ANTS functionality when connected to the ECDIS. The system has inputs for both gyrocompass and magnetic compass heading data. During the normal operating mode the headings from both gyrocompass and magnetic compass are produced in the independent course monitor. In the event of a gyrocompass failure all major receivers of the gyrocompass heading, such as radar, Satcomm, GPS and digital repeaters, can be switched over immediately to the heading from the magnetic compass from the course monitor.
- *Gyrocompass system*. This is a microprocessor-controlled digital system designed as a single unit with control and display unit in the front cover. The control and display unit can be removed from the housing and installed at a position (e.g. a bridge console) remote from the gyrocompass. The gyrocompass has an integrated TMC function, gives a rate-of-turn (ROT) output, has seven independent RS 422 and NMEA 0183 serial outputs and complies with DNV-W1.
- *Magnetic compass*. The system includes aluminium alloy binnacle, magnetic flat glass compass, a fluxgate pick-off with an integrated sine/cosine interface, bypass arrangements, azimuth devices, electronic compasses, and magnetic compass autopilots (TMC). Variation correction, gyro/TMC changeover etc. is incorporated in the gyrocompass monitor/changeover system. System uses gyro repeaters for indication when TMC is selected at the compass monitor.
- *Dual axis Doppler log*. The log is a two-axis system, the data obtained from the speed log is longitudinal and transversal bottom-track speed and depth, and longitudinal water-track speed. The log provides simultaneous W/T and B/T speeds of ±30 knots with 0.1 knot scale and depth. Bottom-track speed and depth are displayed from 3 to 300 m. Data from the log is transmitted to the log processing unit (LPU) which serves as a data concentrator/distributor in the system. The LPU is programmed according to the geometry of the ship and the position of the transducer. With this information the LPU computes transversal speeds of bow and stern. The system comprises two independent log systems each with a dedicated display at the chart table. Log selection for output to other repeaters, integrated bridge system etc. is via a selector switch at this position.
- *Echo sounder*. This unit can be operated as a single or dual frequency unit with up to four transducers. The display offers five basic ranges between 0 and 2000 m. The high resolution LCD display allows continuous observation of bottom recordings and shows all relevant navigation data. The display includes continuous indication of digital depth and range. Bottom alarm can be set at any required depth. The unit can store the last 24 h data together with the position so that a printout can be made if required.
- *DGPS*. The receiver automatically locates the strongest transmitting beacon station and lock on in seconds. In the case of signal loss it automatically switches over to an alternative station ensuring a strong signal at all times. A navtalk NMEA distribution unit is included which is fed with the output from both DGPS receivers and supplies 10 buffered outputs. In the event of failure of the primary DGPS the system automatically switches to the secondary.
- *Loran-C*. The system uses the Furuno LC-90 Mk-II receiver. Full details of this receiver can be found in Chapter 4.
- *Bridge alarm system*. This is a central alarm/dead man system which meets the highest current classification society bridge alarm specification. The system is capable of handling 40 opto-isolated switched inputs. Alarms are managed and displayed in order of priority. It is connected interactively to the integrated navigation system to allow the alarms to be repeated on the ECDIS.

6.10.3 Sperry Marine Voyage Management System – Vision Technology (VMS-VT)

The Sperry VMS-VT system, provided by Litton Marine Services, is a computer-based navigation, planning and monitoring system which typically consists of two or more computer workstations connected by a local area network (LAN). A typical arrangement for a VMS-VT system is shown in Figure 6.7.

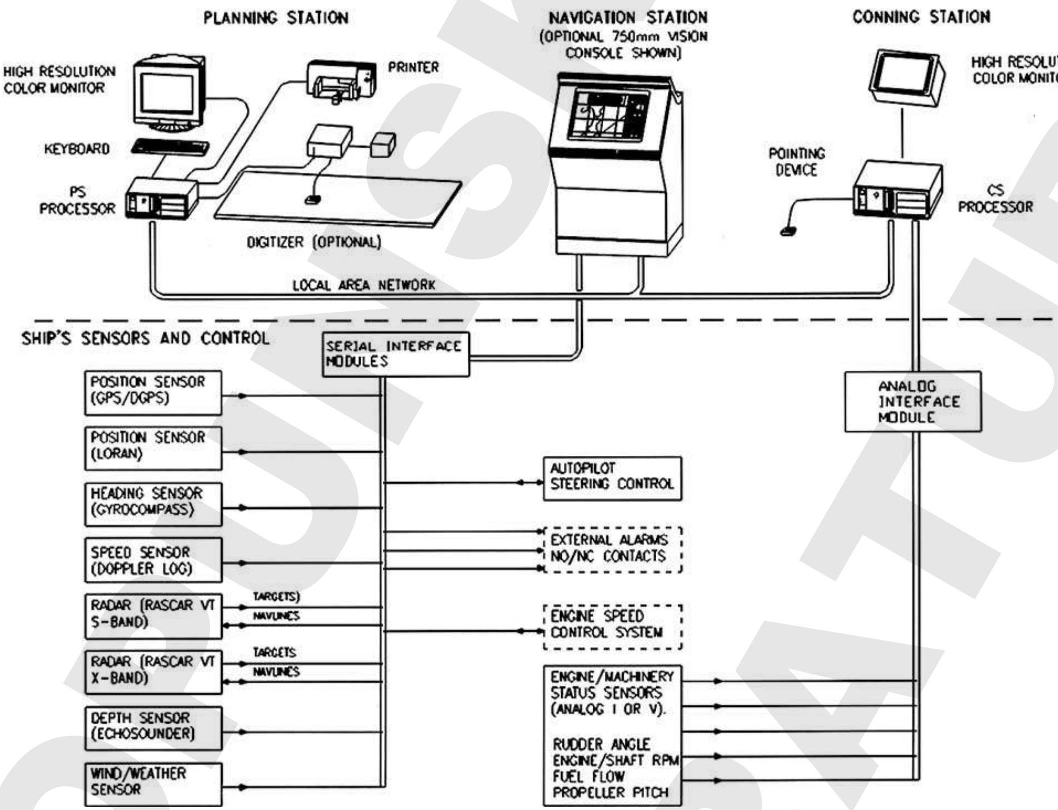


Figure 6.7 Typical arrangement for the Voyage Management System – Vision Technology (VMS-VT). (Reproduced courtesy of Litton Marine Systems.)

Figure 6.7 shows three workstations, providing a navigation station, a planning station and a workstation designated as a conning station. The navigation station is usually located in the conning position. All VMS-VT functions are available at this station except chart digitizing and chart additions.

The planning station is usually located in the chart room and has a high-resolution monitor and printer which can provide hard copies of voyage data. Separating the planning station from the navigation station allows an operator to effect voyage planning or chart editing at the planning station without interfering with conning operations at the navigation station. The display at the navigation station is also available at the planning station so that the ship's position can be monitored at either location. A typical VMS-VT main display is shown in Figure 6.8.

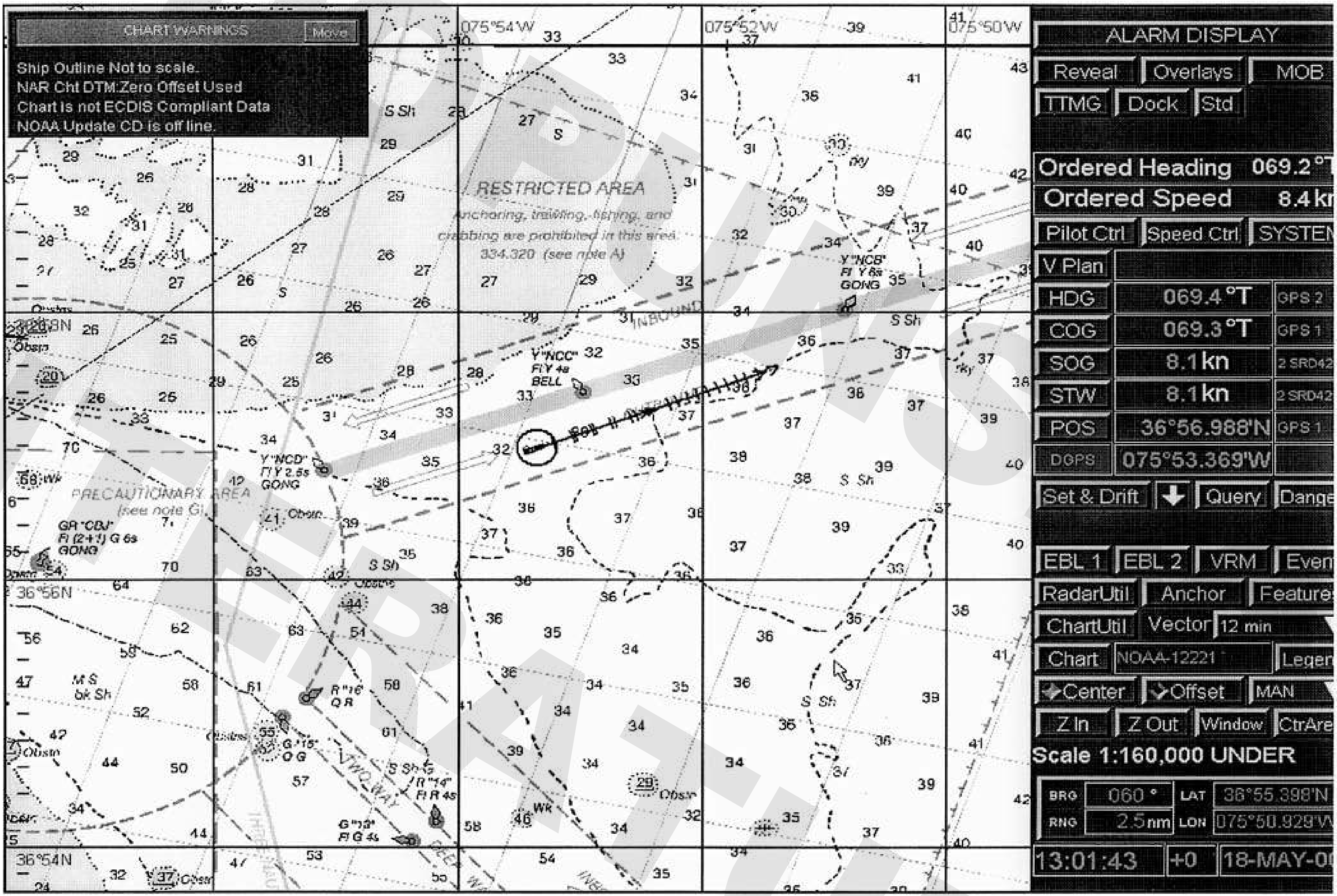
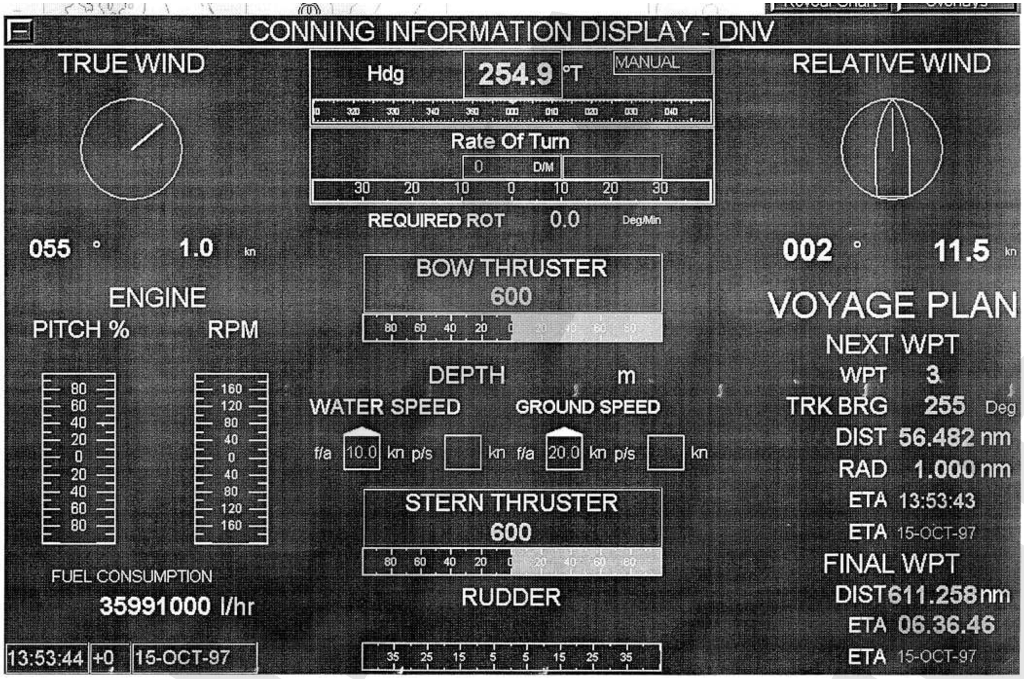


Figure 6.8 VMS-VT main display screen showing own ship's position, heading and speed using an electronic chart. (Reproduced courtesy of Litton Marine Systems.)



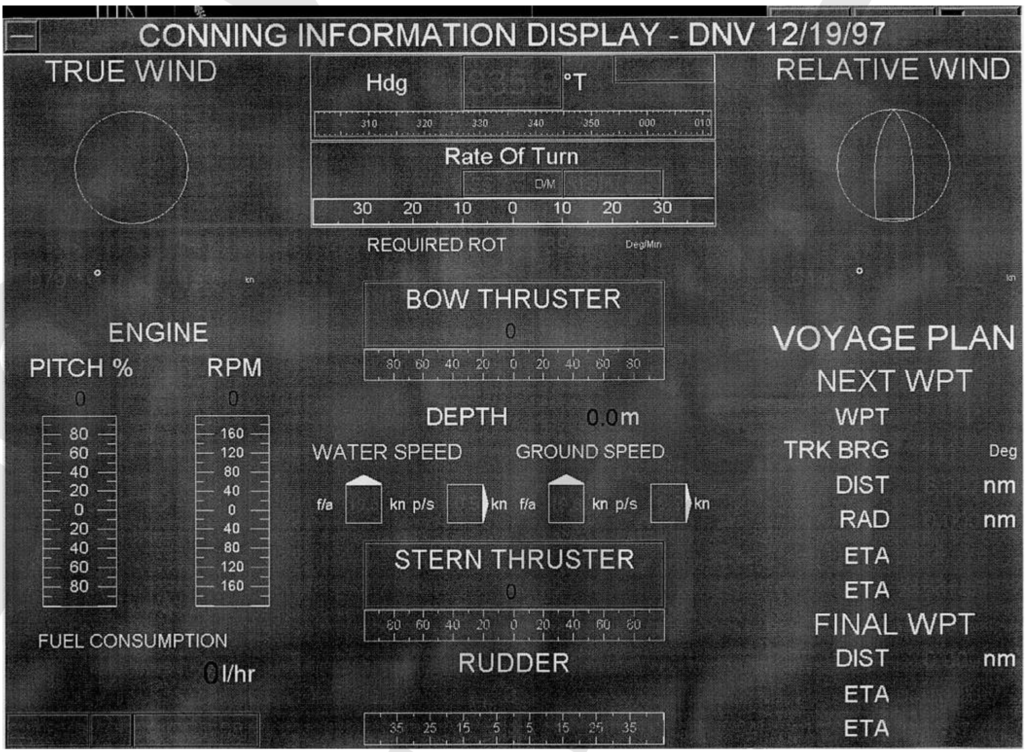


Figure 6.9 Examples of VMS-VT conning information display screens. (Reproduced courtesy of Litton Marine Systems.)

The conning station is usually configured to display a single page of specific navigation data as specified by regulatory group requirements. For this arrangement a pointing device is not provided since the display is non-interactive. At the conning station the screen is known as the conning information display (CID). Where possible the navigational and meteorological digital data is presented on the CID screen graphically to mimic analogue instruments in order to make it easier for an operator to assimilate and manage data quickly. The data presented is updated continuously and has a fixed layout pattern so that particular data is always available at the same location. A similar CID page is often available as a large display overlay screen at the VMS-VT navigation station and planning station (see Figure 6.9).

DNV on the screen displays of Figure 6.9 refers to the classification society Det Norske Veritas, Norway.

An engineering information display, as shown in Figure 6.10, can be provided as a display overlay screen at the VMS-VT navigation station and planning station or as a full-screen display at a dedicated monitor. The system can also be configured to display other pages such as a performance monitor window as shown in Figure 6.11.

As Figures 6.9–6.11 indicate, the main advantage of the VMS-VT system is its flexibility in presenting information that can be displayed in a manner that meets the customer's requirements.

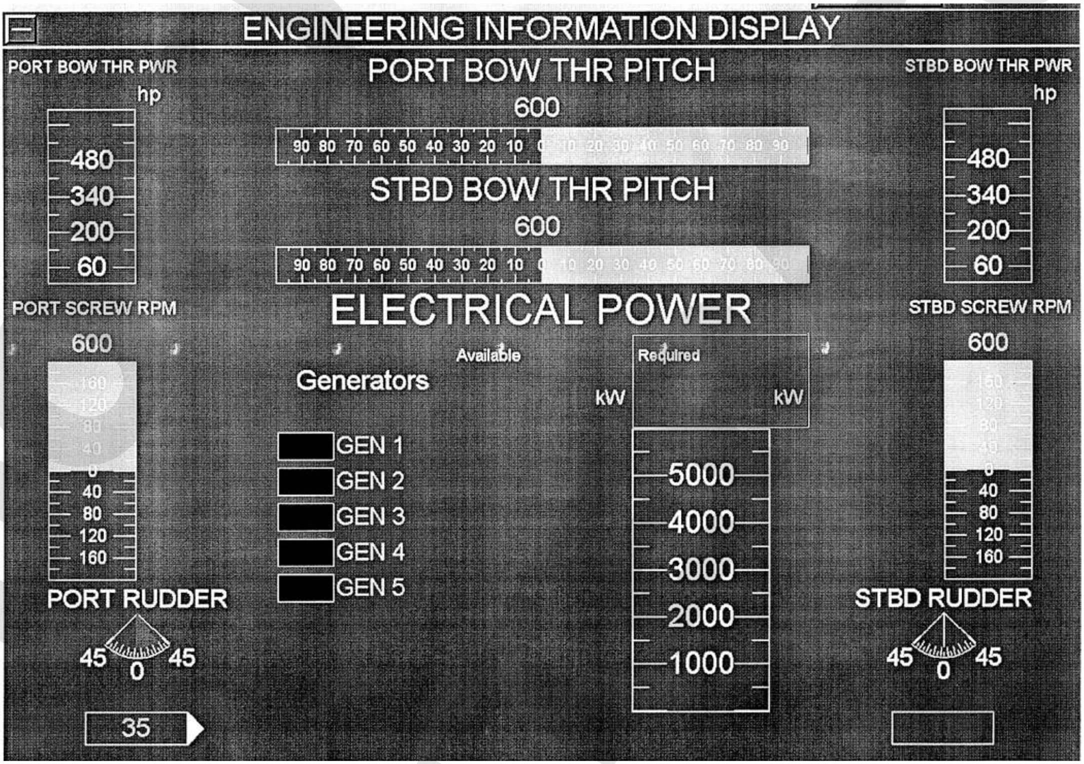


Figure 6.10 Example of VMS-VT engineering information display screen. (Reproduced Courtesy of Litton Marine Systems.)

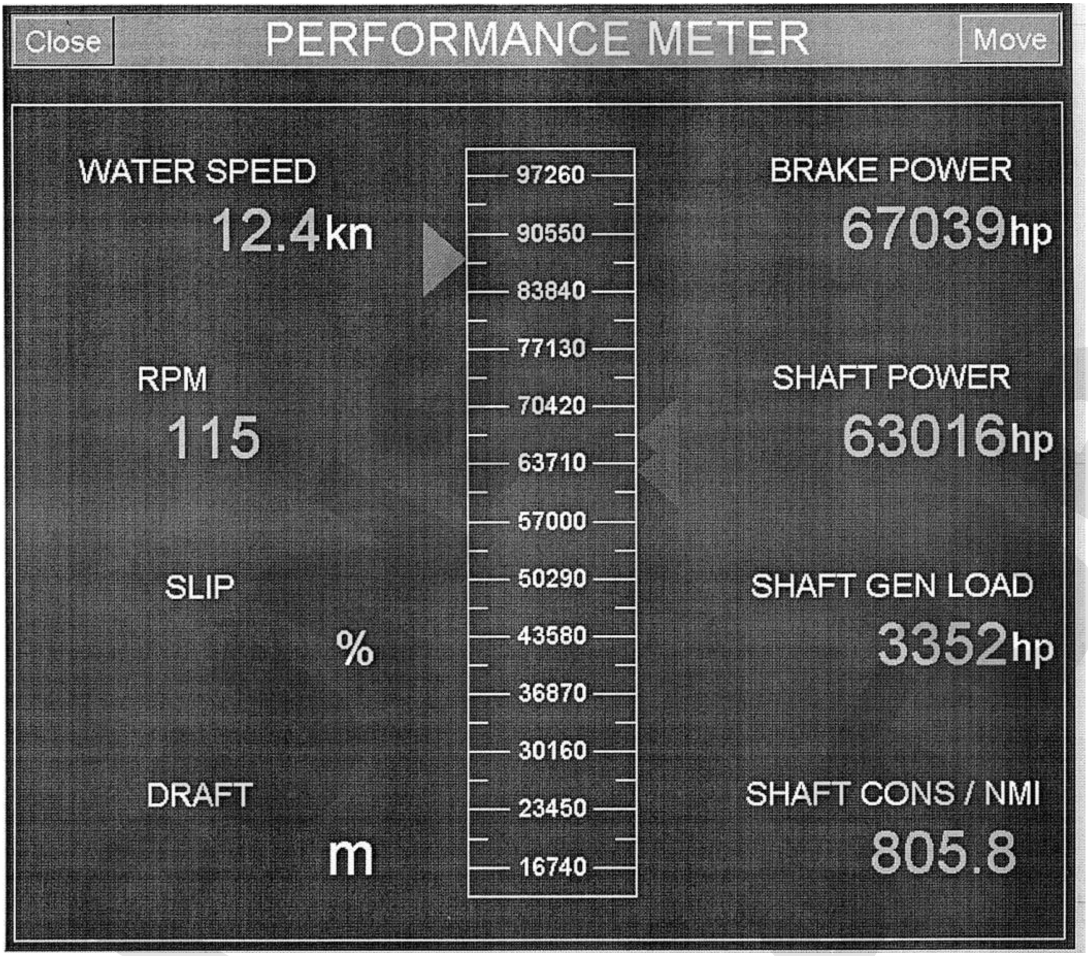


Figure 6.11 Example of VMS-VT performance monitor window. (Reproduced courtesy of Litton Marine Systems.)

Basic VMS-VT functions include:

- integration of data from various sensors
- data sharing on a local area network (LAN)
- display of real-time sensor information
- display of electronic charts with ownship position
- creation of a voyage plan
- execution of a voyage plan
- display of electronic bearing lines (EBLs)
- display of variable range markers (VRMs)
- comprehensive alarm and operator message system
- printing of ship's navigation data.

Optional VMS-VT functions include:

- autopilot control
- speed order control
- display of radar target information
- DNV certified track keeping
- ECDIS S-57 or digital navigational chart (DNC) display
- interface to voyage recorder
- creation and editing of charts using the digitizer or chart additions editor
- providing data to docking displays
- providing precision manoeuvring displays
- man overboard display
- providing data to a conning station
- display of engine room data
- display of meteorological data.

Computers required for essential and important functions are only to be used for purposes relevant to vessel operation and the VMS-VT is normally configured to prevent the operator from installing or running any other application.

A VMS-VT application that includes some of the optional functions mentioned above is shown in Figure 6.12.

Among the displays shown in Figure 6.12 is an ECDIS that uses digital chart data to produce a chart display (see Chapter 7 for more information on ECDIS). The VMS-VT system has the capability to catalogue and display many types of chart formats including commercially available scanned charts produced by official hydrographic offices and/or commercially produced vector charts. Chart formats differ but VMS-VT can be configured at the factory or on the ship to use the chart format specified

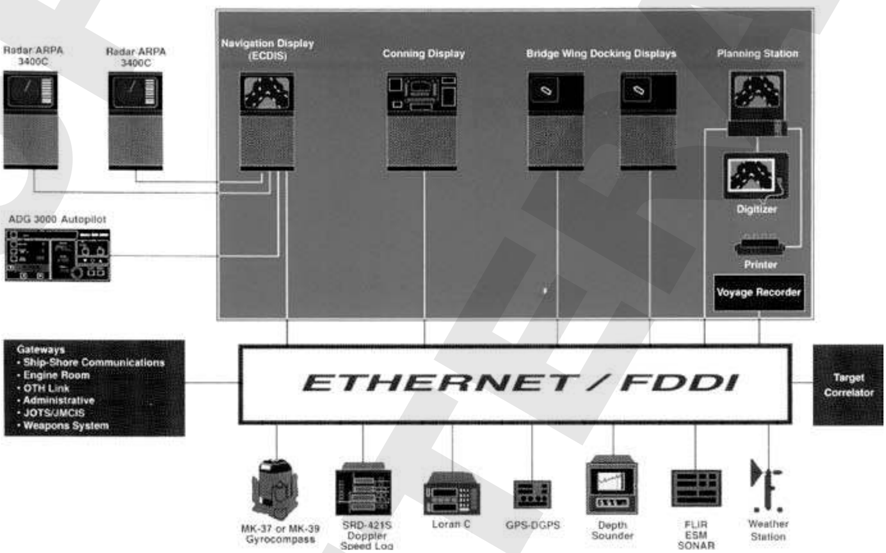


Figure 6.12 Block diagram of the VMS-VT system. (Reproduced courtesy of Litton Marine Systems.)

by the customer. Reference to Chapter 7 will show that an ECDIS must use an electronic navigational chart (ENC) which possesses a single universal data format and they must be 'official' charts in that they are issued on the authority of a government authorized hydrographic office.

Available chart formats include: S57 charts; NIMA (National Imagery and Mapping Agency) DNC charts; British Admiralty ARCS raster charts (BA charts); BSB format charts such as those issued by the National Oceanic and Atmospheric Administration (NOAA); and digitized charts. Electronic charts can be retrieved from CD-ROM disks or from the computer hard disk if the required chart has been stored there.

The VMS-VT Planning Station may include a digitizer pad so that staff can create electronic charts. The digitizer can also be used to edit these electronic charts when a published Notice to Mariners updates the corresponding paper chart. The charts are stored as individual files in the VMS-VT workstations. Those charts digitized at the planning station can be copied to floppy disks for back-up storage and for transfer between ships. A standard 1.44M byte floppy disk can hold about 20 detailed charts. The digitizer can also be used to create navlines with a latitude/longitude reference, which can be transferred and displayed on the RASCAR radars.

Sensor data integration and display

A major feature of the VMS-VT system is the ability to receive sensor data from the local area network and from direct hardware interfaces. The primary type of sensor data processed by the system is navigational information, which includes:

- heading
- speed over the ground
- speed through the water
- geographic position
- set and drift
- course over the ground.

The VMS-VT sorts the data by type and provides a separate source window for each type of data. To display the source window for a particular data type requires the operator to select the appropriate button on the main menu. Each source window lists a group of sensors appropriate to the data type. The present data from each sensor is included in the window so that the best source can be selected from the list. As an example the position source window, as shown in Figure 6.13, is displayed by selecting the POS button on the main menu.

The position source window provides a list of all the configured position sensors along with the present data from each sensor. The operator may select the desired source of position data from this list or may open source windows for other types of navigational data in a similar manner.

Radar target data

The VMS-VT system allows access and display of target information from multiple ARPA radars. The Litton Marine Systems RASCAR radar contains a target data logging switch for the target data logging option. If required, all the connecting RASCAR radars can send their target data allowing the operator to choose the source of ARPA target information. Radar data is automatically processed into a single target list so that if two radars have acquired the same target it will be displayed as one target at the VMS-VT. Symbols representing radar targets are displayed on the electronic chart. Each target symbol includes a speed vector, history dots and an identification number (ID).

A typical bridge layout with VMS-VT installed is shown in Figure 6.14.

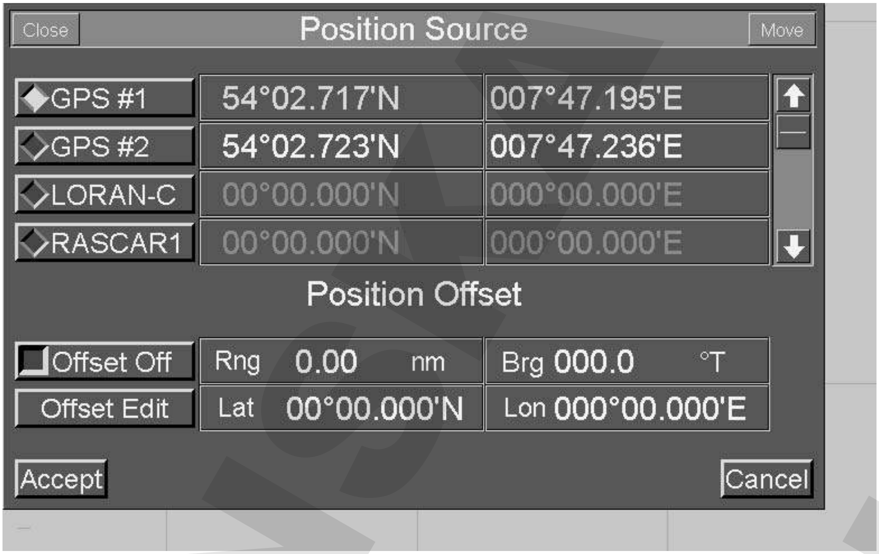


Figure 6.13 Example of VMS-VT position source window. (Reproduced courtesy of Litton Marine Systems.)

Figure 6.14 A typical integrated bridge VMS-VT installation. (Reproduced courtesy of Litton Marine Systems.)