Chapter 6

Integrated bridge systems

6.1 Introduction

The 20th century saw many milestones in terms of nautical events and much was learnt from such events for the benefit of those seafarers that came afterwards. Starting with events such as the sinking of the Titanic in 1912 with its impact on the Safety of Life at Sea, the use of wireless telegraphy and, continuing throughout the century, the increasing use of electronics and satellites for navigation and communication purposes.

During that time there was a realization for the need to set up international bodies with a view to the harmonization, and the international recognition, of standards for ships involved in international trading. Bodies set up during the 20th century to monitor and influence these trends included the following.

6.1.1 International Maritime Organization (IMO)

Originally set up as the Inter-Governmental Maritime Consultative Committee (IMCO) in 1958, the name was changed in 1982. Its first task was to adopt a new version of the International Convention for the Safety of Life at Sea (SOLAS) and this was completed in 1960. The best known of the responsibilities of the IMO is the adoption of maritime legislation. About 40 conventions and protocols have been adopted by the organization and amended as necessary to keep pace with the changes in world shipping. The IMO has 158 member states and is based in London, England.

6.1.2 The International Standards Organization (ISO)

This is a non-governmental organization established in 1947 with a view to promoting the development of standardization in the world, facilitating the international exchange of goods and services, and developing co-operation in the areas of intellectual, scientific, technological and economic activity. The work of the organization results in international agreements, which are published as International Standards. There are more than 130 countries represented within the organization which is based in Geneva, Switzerland.

6.1.3 The International Electrotechnical Commission (IEC)

Established in 1906, the organization has more than 50 member countries covering 85% of the world's population. Standards established are used in more than 100 countries and there are approximately 200 Technical Committees (TCs) of which TC80 is an important part (see Section 6.3). The IEC collaborates with the ISO in matters of mutual interest and both organizations co-operate on a joint

basis with the International Telecommunications Union (ITU). Like the ISO, the IEC is a non-governmental body while the ITU is part of the United Nations organization with governments as its members. The IEC is based in Geneva, Switzerland.

6.2 Design criteria

In the 1960s Planned Ships Bridges were available from at least one manufacturer and fitted on some vessels. This was probably the first attempt to construct a bridge within design concepts that took into consideration the operational requirements of the vessel. Integrated navigation systems and integrated bridge systems have evolved from those days and the concept is now accepted, with a variety of systems available from many different manufacturers.

Certain classification societies have initiated terms of carriage requirements if particular notations are specified for a vessel. A leading influence has been Det Norske Veritas (DNV) of Norway, a member of the International Association of Classification Societies (IACS). The Association was formed in 1968 and claims that 'At the heart of ship safety, classification embodies the technical rules, regulations, standards, guidelines and associated surveys and inspections covering the design, construction and through-life compliance of a ship's structure and essential engineering and electrical systems.' More than 90% of the world's merchant tonnage is classed by the 10 members and two associates of IACS. IACS members include the American Bureau of Shipping (ABS), Germanischer Lloyd and Lloyds Register of Shipping, together with societies from China, France, Italy, Japan, Korea, Norway and Russia. IACS has held consultative status with the IMO since 1969 and is the only non-government organization with observer status able to develop rules. The DNV rules for ships are as follows.

- To reduce the risk of failure in bridge operation, causing collisions, groundings and heavy weather damages and to minimize the consequences to ship and complement, should an accident occur.
- To include relevant requirements and recommendations from the IMO.
- To include relevant international standards within the rules or indicating the points in which they differ.

The various classification societies have adopted different standards although discussions on establishing international performance standards for integrated bridge systems have progressed under the direction of the IEC's Technical Committee 80 (TC80). Progress has been made on type approval and system notation.

The integrated bridge system should be designed and installed as a physical combination of equipment or systems using interconnected controls and displays. Workstations should provide centralized access to all nautical information. The type of operational function carried out from the bridge would include navigation, communications, automation and general ship operation. Manufacturers can provide shipbuilders and potential shipowners with computer-generated drawings of how a particular bridge layout would look when installed. One such diagram produced by Litton Marine Systems is shown in Figure 6.1.

In the absence of any internationally-agreed operating standards, from either the IMO or national authorities, reliance must be placed on industry guidelines and standards which do exist for bridge layout and equipment. These include the ISO standard for 'bridge layout and associated equipment.'

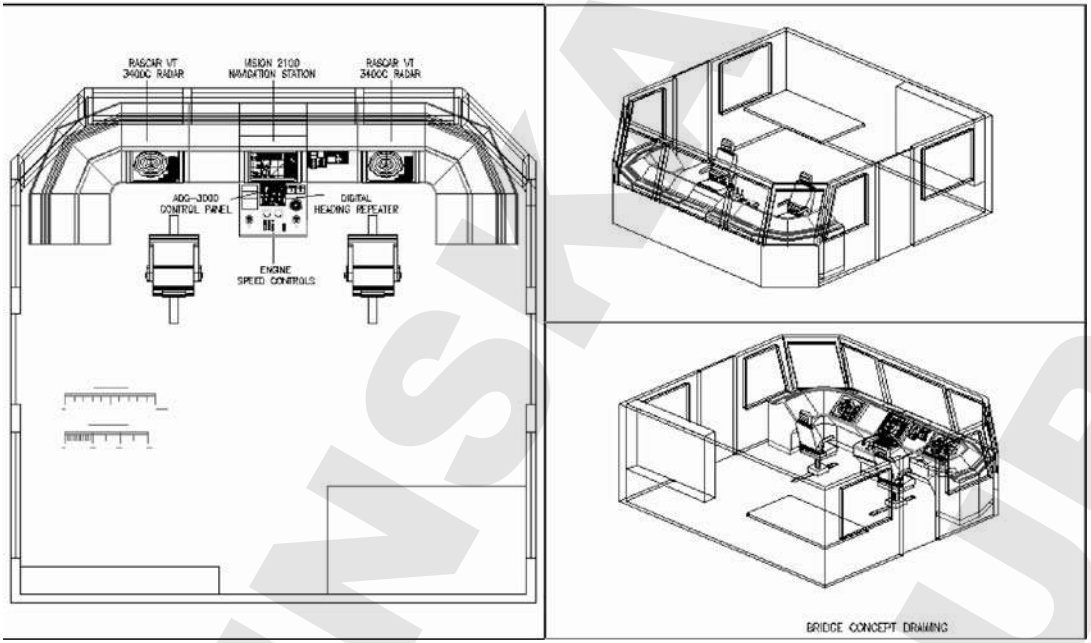

Figure 6.1 Line drawing of an integrated bridge system. (Reproduced courtesy of Litton Marine Systems.)

An IEC definition of an integrated bridge system states that such a system must be capable of carrying out at least two of the following functions:

- navigation planning
- passage execution and manoeuvring
- collision and stranding avoidance
- communications
- machinery control and monitoring
- loading and discharge of cargo
- safety and security
- management.

The integrated bridge system that meets these requirements must provide: redundancy in the event of system failure; the use of standardized equipment interfacing; the centralization of all nautical data and alarms; and the use of suitable displays to allow the monitoring of sensor data. The fact that current trends involve a reduction in manning levels suggests that the few members of a crew on the bridge must be capable of interpreting and responding to the multitude of information and alarms being presented to them. This would involve improvements in training and system documentation for the crews.

The DNV rules specify design criteria for particular workstations namely:

- traffic surveillance/manoeuvring
- navigation

- route planning
- manual steering
- safety operations
- docking operations
- conning operations.

In each case the tasks that have to be performed are specified and the siting of relevant instruments/ equipment required for those tasks is defined. As an example, the workstation for navigation is specified to enable the following tasks to be performed:

- determine and plot the ship's position, course, track and speed;
- effect internal and external communications related to navigation;
- monitor time, course, speed and track, propeller revolutions, pitch indicator and rudder angle.

The following instruments and equipment should be installed within reach:

- navigation radar display and controls
- chart table
- relevant position fixing systems (GPS and Loran-C)
- VHF unit
- whistle control.

Instruments, indicators and displays providing information considered essential for the safe and efficient performance of tasks at the navigation workstation should be easily readable from the workstation. These instruments, indicators and displays should include:

- gyro repeater
- rudder angle indicator
- depth indicator
- clock
- propeller RPM indicator
- pitch indicator (where fitted)
- speed and distance indicator.

Means to be used at intervals for securing safe course and speed in relation to other ships and safety of bridge operation should also be easily accessible from the navigation workstation. Such means include:

- instruments and equipment installed at the workstation for traffic surveillance/manoeuvring
- internal communications equipment
- central navigation alarm panel (if provided)
- wipers and wash controls for the windows within the required field of vision.

DNV specification for one-man bridge systems in an unbounded voyage area, known as DNV-W1, requires an Automatic Navigation and Track-keeping System known as ANTS. The specification requires integration of the following:

- Electronic Chart Display and Information System (ECDIS)
- automatic steering system (including software for calculation/execution of adjustments for the maintenance of pre-planned routes)

- differential GPS (2)
- gyrocompass (2)
- speed over ground (SOG) and speed through water (STW)
- course alteration warnings and acknowledgement
- automatic safety contour checking and alarming during voyage planning and execution
- capacity to create own electronic charts from paper charts for areas not covered by ENCs issued or certified by official sea chart authorities.

In addition to the above functional requirements, ANTS also places great emphasis on suitable technical documentation.

The requirements for ANTS place additional demands on certain aspects of the system. For example, the accuracy of the ship's heading should be a value that has been corrected for any errors typical of the source of the heading input, and at least one of the gyrocompasses should be provided with an automatic system for the correction of errors caused by speed and latitude. The steering system should also keep automatic track-keeping of the ship within the limits set on both sides of the pre-planned track and should provide the capability to steer the ship along a route consisting of straight and curved lines by both automatic and manual input of turn orders. The speed input should have sufficient accuracy to safeguard the quality of position fixing by dead reckoning. The system should be provided with a filtered position from the GPS receiver and when performing turns, the system should be provided with the most accurate real-time position. The quality of the integrated position fixing system should be monitored and a warning should appear if the quality is below an acceptable limit.

The need for integration has meant that there has been a tendency to move away from sourcing equipment from a variety of manufacturers and attempts to integrate disparate pieces of equipment, to single-sourcing a package of equipment from just one manufacturer. Many manufacturers, aware of the requirement, now offer complete systems with all the necessary interfacing requirements guaranteed. The use of standard modules and interfaces, not only for navigation but also for other bridge functions, such as communications, engine monitoring and control, power supply etc., is likely to produce cost savings and reduce the amount of equipment required. Factors such as the reduced number of consoles, reduced installation and interfacing costs, more cost-effective design, installation and testing requirements have to be taken into account.

6.3 Standards

Those organizations involved in the production of world standards are the International Standards Organization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunications Union (ITU). The first two organizations work closely together and, as they both have their headquarters in Geneva, some facilities have been amalgamated.

The International Maritime Organization (IMO) is responsible for defining the requirements for marine equipment but it does not provide sufficient specification detail for manufacturers to design specified equipment or for national maritime authorities to provide test and approval facilities for the equipment. Thus, the IEC and ISO standards are designed to allow the necessary specification requirements for design, testing and approval.

The IEC has several Technical Committees working in specialized technical areas. The IEC Technical Committee 80 (IEC TC80) covers the area of 'Marine Navigation and Radio communication Equipment and Systems' and was formed in 1980. IEC TC80 responsibility is to concern itself with the development of international technical standards for the navigation and radio communication equipment designated by the IMO for mandatory carriage on vessels covered by the SOLAS (Safety of Life at Sea) Conventions.

IEC TC80 currently has 10 working groups:

- WG1 radar and ARPA
- WG1A Track control
- WG4 Terrestrial position-fixing aids
- WG4A Global Navigation Satellite Systems (GNSS)
- WG5 General requirements
- WG6 Digital interfaces
- WG8 Global Maritime Distress and Safety System (GMDSS)
- WG8A Automatic shipborne Identification Systems (AIS)
- WG10 Integrated navigation systems
- WG11 Voyage data recorders.

Until fairly recently there were two other TC80 working groups: WG7 Electronic chart display and information system (ECDIS) and WG9 Integrated bridge systems for ships. The latter group was responsible for the publication in April 1999 of IEC 61209 'Maritime navigation and radio communication equipment and systems – Integrated bridge systems (IBS) – operational and performance requirements, methods of testing and required test results'. This document covers features such as: data exchange, displayed information, system configuration, human factors, alarms, training facilities, power supplies and failure analysis. This latter point is doubly important as it has implications in other areas such as training facilities.

6.4 Nautical safety

All aspects of bridge operation have evolved because of the requirement for the safety of the ship, crew and, where applicable, the passengers. The safety philosophy is encapsulated within the rules of Det Norske Veritas (DNV) and the following is reproduced from the DNV rules, part 6, chapter 8 with their kind permission.

6.4.1 Safety philosophy

To achieve optimum safety and efficiency in bridge operation the rules address the total bridge system, which is considered to consist of four essential parts.

- The technical system which deduces and presents information as well as enabling the proper setting of course and speed.
- The human operator who is to evaluate available information, decide on the actions to be taken and execute the decisions.
- The man/machine interface which safeguards that the technical system is designed with due regard to human abilities.
- The procedures which shall ensure that the total bridge system performs satisfactorily under different operating conditions.

6.4.2 Scope of rule requirements

These are set out in each section of the Rules for Nautical Safety and reflect the different factors that affect the performance of the total bridge system and are intended to regulate the following areas.

- Design of workplace, based on the analysis of functions to be performed under various operating conditions and the technical aids to be installed.
- Bridge working environment, based on factors affecting the performance of human operators.
- Range of instrumentation, based on information needs and efficient performance of navigational tasks.
- Equipment reliability applicable to all types of bridge equipment, based on common requirements to ensure their suitability under various environmental conditions.
- Specific requirements to different types of bridge equipment, based on the facilities required for the performance of their specific functions.
- Man/machine interface, based on the analysis of human limitations and compliance with ergonomic principles.
- Qualifications, based on the competence required for mastering rational navigational methods and relevant technical systems installed on board the ship.
- Operating procedures, based on the work organization needed to make the bridge system function under different operational situations.
- Information on the ship's manoeuvring characteristics, based on the manoeuvres commonly used in various operational situations.
- Tests and trials for new ships, based on the need to ensure that technical systems perform in accordance with their specifications before being relied upon and used in practical operation.
- Reporting system, from ships in service, on bridge instrument failures, based on the information needed to detect their factual reliability level.
- Survey schemes for ships in service, based on the follow-up and testing required to safeguard that bridge systems maintain their reliability.

6.5 Class notations

The Rules for Nautical Safety are divided into three class notations. Two class notations represent the minimum requirements within bridge design, instrumentation and procedures whereby NAUT-C covers bridge design and W1-OC, in addition, includes instrumentation and bridge procedures. The third class notation, W1, extends the basic requirements for bridge design and instrumentation and additionally requires information on the manoeuvring characteristics of the ship and an operational safety manual for safe watchkeeping and command of the ship.

NAUT-C covers bridge design, comprising the following main areas:

- mandatory and additional workstations
- field of vision from workstations
- location of instruments and equipment.

W1-OC covers bridge design, instrumentation and bridge procedures comprising the following main areas:

- NAUT-C
- range of instrumentation
- instrument and system performance, functionality and reliability
- equipment installation
- monitoring and alarm transfer system
- procedures for single-man watchkeeping.

W1 covers W1-OC and extensions within the following areas of W1-OC:

- design of one-man workstation
- field of vision astern
- range of instrumentation
- instrument performance
- automation level
- qualifications.

Also covered is information on the manoeuvring characteristics of the ship comprising the following main items:

- speed at different settings
- steering ability
- turning ability
- stopping ability.

There is also a requirement for an operational safety manual comprising the following main items:

- bridge organization and responsibilities
- watchkeeping procedures
- system fall-back procedures
- accident and emergency procedures.

6.6 Bridge working environment

Ships requesting class notation NAUT-C, W1-OC or W1 should comply with rules for bridge working environment which specifies vibration levels, noise, lighting, temperature, ventilation, surfaces, colours and the safety of personnel.

6.6.1 Equipment carriage requirements

Ships requesting class notation W1-OC are equipped with the following systems:

- course information systems (two gyrocompasses or one gyro + one TMC)
- steering systems (manual and automatic steering)
- speed measuring system (water speed, > 40 000 tons gross, dual axis)
- depth measuring system (over 250 m length, two transducers)
- radar systems (two radars, at least one X-band)
- traffic surveillance systems (ARPA)
- position fixing systems (Loran-C, GPS)
- watch monitoring and alarm transfer system
- internal communication systems
- nautical safety radio communication systems
- sound reception system (technical device to receive signals).

Additional equipment required for class notation W1 includes:

- steering system with rate of turn indicator
- course information system, which should have two independent gyrocompasses
- speed measuring system, through the water, which should provide information for traffic surveillance system
- Electronic Chart Display and Information System (ECDIS)
- Automatic Navigation and Track-keeping System (ANTS)
- conning information display
- central alarm panel
- wind measuring system.

6.6.2 General bridge equipment requirements

The rules specify the following:

- environmental conditions
- location and installation of equipment
- electrical power supply, alarms, performance confirmation and failure protection
- computer-based systems and software quality.

6.6.3 Specific requirements for different types of bridge equipment

Ships requesting class notation W1-OC shall comply with specific requirements for the following systems:

- course information system (speed and latitude correction)
- steering systems (manual override control and rate of turn display)
- speed measuring system (if bottom track then up to 200 m depth)
- depth measuring system
- radar systems (two floating EBLs, interswitch, ship track monitoring)
- traffic surveillance systems (ARPA with two guard zones)
- position fixing systems (performance standards)
- watch monitoring and alarm transfer system
- internal communication systems
- nautical communication systems
- sound reception system.

Class notation W1 requires in addition the following systems:

- Electronic Chart Display and Information System (ECDIS)
- Automatic Navigation and Track-keeping System (ANTS)
- conning information display
- central alarm panel.

6.6.4 Man/machine interface

Ships requesting class notation W1-OC or W1 must comply with the rules in this section. All instruments must be logically grouped according to their functions within each workstation. Their

location and design should give consideration to the physical capabilities of the human operator and comply with accepted ergonomic principles. The amount of information to be presented for conducting the various tasks, as well as the methods of displaying the information needed, should give consideration to the capabilities of the human operator to understand and process the information made available. The rules specify the following:

- instrument location and design
- illumination and individual lighting of instruments
- requirements for the man/machine dialogue of computer-based systems.

6.7 Ship manoeuvring information

Ships requesting class notation W1 must comply with rules for manoeuvring information.
Information about the ship's manoeuvring characteristics, enabling the navigator to safely carry out manoeuvring functions, shall be available on the bridge. This section deals with: the manoeuvring information to be provided, and the presentation of the manoeuvring information.

The provision of manoeuvring information should include:

- speed ability
- stopping ability
- turning ability
- course change ability
- low-speed steering abilities
- course stability
- auxiliary manoeuvring device trial
- man-overboard rescue manoeuvre.

The presentation of manoeuvring information should include:

- pilot card
- wheelhouse poster
- manoeuvring booklet.

6.8 Qualifications and operational procedures

Class notation W1-OC specifies responsibilities of shipowner and ship operators, qualifications and bridge procedures. Class notation W1 has extensions to responsibilities, qualifications, bridge procedures, and a special requirement for operational safety standards.

6.8.1 Operational safety manual

This is a requirement for class notation W1 to obey the following guidelines.

1 Organization:
   - general
   - bridge organization

- responsibilities of shipowners and ship operators
- responsibilities of the master
- responsibilities of the officer in charge of single-man watchkeeping
- qualifications of bridge personnel
- manning
- safety systems – maintenance and training.

2 Daily routines:
- general
- look-out
- changing of the watch
- periodic checks of navigational equipment
- log-books
- communications and reporting.

3 Operation and maintenance of navigational equipment:
- general
- radars/ARPA
- automatic pilot
- gyro and magnetic compasses
- echo sounder
- speed/distance recorder
- electronic position fixing aid
- electronic navigational chart
- automatic navigation and track-keeping system
- hydrographic publications
- emergency navigation light and signal equipment.

4 Departure/arrival procedures:
- general
- preparation for sea
- preparation for arrival in port
- embarkation/disembarkation of pilot
- master/pilot information exchange.

5 Navigational procedures:
- general
- helmsman/automatic pilot
- navigation with pilot embarked
- navigation in narrow waters
- navigation in coastal waters
- navigation in ocean areas
- navigation in restricted visibility
- navigation in adverse weather
- navigation in ice
- anchoring.

6 System fall-back procedures:
- general
- bridge control/telegraph failure
- gyrocompass failure
- steering failure
- auxiliary engine failure
- main engine failure.

6.8.2 Contingency and emergency manual

1 Contingency and emergency organization:
- general
- duties and responsibilities.

2 Accident procedures:
- general
- collision
- grounding
- fire/explosion
- shift of cargo
- loss of buoyancy/stability.

3 Security procedures:
- general
- sabotage threat/sabotage
- hijacking threat/hijacking
- piracy
- local war situation
- criminal act committed on board
- detention/arrest.

4 Emergency procedures:
- general
- emergency notification
- abandon ship preparations
- lifeboat evacuation
- helicopter evacuation
- use of other evacuation equipment.

5 Miscellaneous:
- general
- dead or injured person aboard
- man overboard
- search and rescue actions
- stowaways
- political refugees
- missing or lost person
- documentation and reporting
- press releases.

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.