4 OPERATION AND MAINTENANCE OF BRIDGE EQUIPMENT

4.1 GENERAL

The consequences of over reliance on automatic systems for navigation and collision avoidance may be severe and include the risk of collision, grounding and pollution.

Masters and watchkeeping officers should be trained and competent in the use of the ship's navigation and bridge equipment and be familiar with its operation (see Section 1.2.8 & Checklists B3 & B4). This should include understanding:

- The contents and use of operating manuals with particular reference to configuring safety critical features;
- How equipment and software updates are managed and how to verify that updates have been applied;
- Procedures for identifying equipment failures and responding to them; and
- The capabilities and limitations of systems and equipment.

This Guide is complementary to, and should be used in conjunction with, manufacturers' operating and maintenance manuals and specific user policies, which should be included in the SMS.

4.1.1 CARRIAGE REQUIREMENTS

Masters and officers in charge of the navigational watch should be familiar with the relevant carriage requirements which apply to their ship.

4.1.2 EQUIPMENT PERFORMANCE

Periodic checks on equipment should be carried out and any defects reported to the Master. Defects should also be recorded in the log book and as appropriate identified on the Pilot Card (see Checklist A2).

Regular preventive maintenance of all equipment should be carried out according to shipboard maintenance procedures, making use of manufacturers' instructions and manuals.

4.1.3 SOFTWARE ANOMALIES

Computer systems are widely used to support navigation, communications and cargo management. For safe and efficient operation, such systems rely on the suitability and stability of their software. There have been instances when deficiencies in the design or operation of software have led to the system being compromised, with the safety of the ship potentially being at risk. Such deficiencies are widely known as software anomalies.

In order to detect and appropriately manage software anomalies it is recommended that:

- Shipboard familiarisation should equip the Master and watchkeeping officers with an understanding of the normal operating condition of equipment;

- Any deviation from the normal or anticipated operation of software should be investigated to identify the cause(s) and remedial measures implemented in accordance with available guidance;
- New or otherwise previously unknown software anomalies should be reported to the equipment manufacturer; and
- Masters and watchkeeping officers should be familiar with guidance available, including from equipment manufacturers, regarding the identification, mitigation and the reporting channels for anomaly related issues.

Masters and watchkeeping officers should be familiar with and practise procedures within the SMS to monitor the performance of shipboard equipment.

4.1.4 ECDIS ANOMALIES

A number of ECDIS operating anomalies have been identified and subsequently addressed through software updates[8] (see Section 4.13.3). The International Hydrographic Organization (IHO) has produced an ECDIS Data Presentation and Performance Check in Ships[9] that is designed to alert watchkeeping officers to the possibility that the installed ECDIS software may require an update from the manufacturer.

The ship's SMS should contain procedures to ensure that:

- ECDIS data presentation and performance checks are conducted following a software update, ECDIS upgrade or at any time when the Master or watchkeeping officers have concerns over the performance of the ECDIS on board; and
- Any occurrence of apparently new or known, but insufficiently addressed, anomalies is reported directly to the relevant manufacturer[10] and to the IHO[11].

ECDIS is a complex system and it is possible that further anomalies may be identified. However, it is also possible that through misinterpretation of information and/or inappropriate system settings, OOWs can also affect the safe and efficient operation of navigation and related systems. The importance of effective generic ECDIS training and familiarisation with ECDIS, as installed on board, to avoid this potential problem is emphasised (see Section 1.2.8).

4.1.5 CYBER SECURITY

The exchange of electronic data between ships and shore authorities, service providers, charterers and owners/operators has increased significantly over recent years. The use of electronic data exchange, including updates to navigational systems and software, exposes users to the possibility of unauthorised or malicious access. This creates a risk to the safety and security of shipboard systems.

In order to protect commercial interests, as well as to ensure that safety and environmental protection are not compromised, it is important that seafarers comply with Company cyber security procedures. Company procedures should take into account industry guidelines as well as any regulatory requirements addressing cyber security.

8 IMO Circular MSC.1/Circ.1503 ECDIS - Guidance for Good Practice.

9 The ECDIS Data Presentation and Performance Check in Ships and feedback form can be downloaded from www.iho.int.

10 Contact information for manufacturers is contained in the list of the latest versions of ECDIS software, which can be downloaded from www.iho.int.

11 Contact e-mail: info@iho.int.

4.2 STEERING GEAR AND AUTOMATIC PILOT

4.2.1 OPERATION AND TESTING

The OOW should ensure that requirements for the operation and testing of the steering gear are followed (see Checklist B1) and in particular:

- In restricted waters or restricted visibility, an additional steering gear power unit is in operation when such units are capable of simultaneous operation; and
- The complete steering system is tested within 12 hours prior to departure.

4.2.2 STEERING CONTROL

Steering control of the ship will usually comprise manual steering and an automatic pilot (autopilot) or other track control system. At each steering position there should be a gyro repeater and rudder angle indicator.

If an autopilot is fitted, a steering mode selector switch for changing between automatic and manual steering, and a manual override control to allow immediate manual control of the steering, should be available.

In an emergency, steering control may require use of alternative power supplies, auxiliary steering gear or direct control of the steering gear in the steering compartment.

4.2.3 AUTOPILOT - HEADING CONTROL

Heading control will steer to maintain the ship's heading but, unlike automatic track-keeping, does not have the ability to compensate for the effects of wind and tidal-stream/current on the ship's course over ground (COG).

4.2.4 AUTOPILOT - AUTOMATIC TRACK-KEEPING

Automatic track-keeping steers the ship towards a waypoint or to follow a route whilst remaining within a specified cross track distance (XTD). The ship will steer to maintain a COG which keeps the ship on track and moving towards the next waypoint.

An autopilot performing automatic track-keeping functions and its alarm outputs should always be monitored closely, particularly to ensure that the OOW is able to check that it is safe for the autopilot to make an alteration of course.

The ability of the autopilot to follow a planned track closely will depend upon the accuracy of the cross track error (XTE) information sent to the autopilot from the navigation system.

4.2.5 OFF-COURSE ALARM

As part of the steering control system, there is an off-course alarm to warn the OOW when the ship deviates from its heading.

Examples of appropriate independent devices include:

- A magnetic off-course alarm independent from other bridge equipment and inputs; and
- A second gyro compass or transmitting heading device, as appropriate, with a heading comparison unit connected to both compasses.

The alarm should be in use at all times when the autopilot is in operation, and should also be integrated with the BNWAS.

It should be noted that the off-course alarm may not always sound when the ship deviates from its planned track. The ship may be moved off track by wind and tidal stream/currents even though the heading remains unchanged.

The use of an autopilot and the off-course alarm does not relieve the OOW from frequently checking that the planned course is safe and is being maintained.

4.2.6 BERTHING SYSTEMS

There are a range of highly accurate berthing systems available which allow precise approach to a berth usually for specific ship types or in particular locations. Such systems may use laser, doppler or GNSS technology to measure accurately the ship's movements relative to the berth or another ship.

The Bridge Team should be aware of the type of systems in use and their capabilities and limitations.

4.3 COMPASS SYSTEMS

4.3.1 MAGNETIC COMPASS

The magnetic compass is generally fitted above the navigating bridge on the centreline and fitted with a periscope so that the compass is readable from the helmsman's position.

Where the magnetic compass is needed to provide heading outputs to other bridge systems, a transmitting magnetic compass (TMC) is fitted. TMC outputs should be corrected for compass error and the TMC should be tested once a week.

A compass deviation card should be maintained on the bridge. The deviation will need to be determined and the compass adjusted at intervals during the ship's life, particularly after any major steel conversion work to the ship. Particular caution should be observed when using the magnetic compass on ships that carry or have recently carried magnetic cargoes such as iron ore and steel.

Compass safe distances are specified on all electrical bridge equipment and provide the minimum distances from the magnetic compass that equipment can be installed.

A TMC may have variation automatically applied. However, this correction will not include deviation. When correcting TMC outputs for compass error, care should be taken to ensure that the correct values for variation and deviation are applied.

4.3.2 GYROCOMPASS

The gyro compass should be run continuously. Should a gyro compass stop for any reason, it should be restarted and subsequently regularly checked and only relied on again when it has "settled" and the error is known.

Where the gyro has no direct speed log or position input, manual corrections should be made as required.

The gyro will usually support a number of repeaters, including a required repeater at the emergency steering position. Gyro repeaters on the bridge should be checked against the main gyro at least once per watch and after significant manoeuvring. Other repeaters should be checked frequently.

4.3.3 GNSS COMPASS

A Global Navigation Satellite System (GNSS) compass provides an alternative to a gyro compass as a non-magnetic transmitting heading device able to provide heading data to AIS, radar and automatic plotting aids. A GNSS compass or equivalent is required on ships navigating in Polar Waters at latitudes above 80 degrees.

4.3.4 COMPASS ERRORS

As a safeguard against any wandering from the correct heading going undetected, gyro and gyro repeater headings should be frequently checked.

Magnetic and gyro compass errors should be checked and recorded each watch, where possible, using either azimuth or transit bearings.

A deviation card for the magnetic compass should be maintained and be available to the Bridge Team.

4.3.5 RATE OF TURN

When ships are manoeuvring, particularly large ships where the distance between the bow and the pivot point of the ship is considerable, rate of turn indication provides feedback on how quickly the ship is turning. Rate of turn measurement is used by automatic track-keeping systems to perform controlled turns.

4.4 SPEED AND DISTANCE LOG

Speed and distance measuring equipment, depending upon type, will provide measurement of speed and distance travelled through the water or over the ground.

4.4.1 SPEED MEASUREMENT

Speed over the ground (SOG) is the speed of a vessel referenced to the surface of the earth. Speed through the water (STW) is the speed of a vessel referenced to the water in which it is navigating.

In general, STW is used for radar collision avoidance and SOG is used for navigation. Caution should be exercised if SOG is used for collision avoidance as differences can arise in the aspect of a target and its vector particularly due to strong cross tides.

Speed made good (SMG) can be measured from two fixed points on a chart, and is also calculated and transmitted by electronic position fixing systems.

4.4.2 TYPES OF SPEED LOG

Electromagnetic and doppler type logs can be either single-axis and measure speed in the fore and aft direction (longitudinal) or dual-axis and measure fore and aft (longitudinal) and also athwartships (transverse) movement. When connected to rate of turn data, dual-axis logs are also able to calculate the speed and direction of movement of the bow and stern.

4.4.3 RECORDING OF DISTANCE TRAVELLED

Log distances should be recorded in the log book at the end of each watch. To ensure the accuracy of recorded speed and distance log equipment, it should be installed, maintained and calibrated in accordance with manufacturers' instructions.

4.5 ECHO SOUNDERS

Cargo vessels of 300 gross tonnage and above and all passenger vessels are required to carry an echo sounder for measuring the depth of water. The echo sounder should have a minimum of two range scales: shallow (20m) and deep (200m).

The echo sounder should always be used when making a landfall and kept switched on in coastal and pilotage waters. If the echo sounder is fitted with a shallow water alarm, the alarm should be set to an appropriate safe depth to warn of approaching shallow water.

Care should be taken to check that the units of soundings on the echo sounder are the same as those used on the chart in use. When comparing echo and chart soundings, due allowance should be made for the draught of the ship, any depth reading offset, and height of tide.

4.6 BRIDGE NAVIGATIONAL WATCH ALARM SYSTEM

The Bridge Navigational Watch Alarm System (BNWAS) monitors bridge activity and OOW awareness, and can detect operator disability which could lead to marine accidents. The system uses stages of visual and audible alarms to alert the Bridge Team. If for any reason the OOW does not respond or is incapable of responding, the Master and/or other appropriate personnel will be automatically alerted.

The BNWAS alert period should be sufficient so that alarms do not unnecessarily distract the OOW from watchkeeping duties.

Additionally, the BNWAS can provide the OOW with a means of calling immediate assistance to the bridge.

The BNWAS should be operational whenever the ship is underway, particularly when the autopilot is in operation, and may be used at anchor.

4.7 NAVIGATION LIGHTS AND SIGNALLING EQUIPMENT

The OOW is responsible for ensuring that the navigation lights, emergency navigation lights and signalling equipment are in working order and are ready for immediate use at all times.

The condition of lights, flags and shapes should be checked at regular intervals.

Sound signalling equipment should be checked daily and maintained in an operational condition.

4.8 VOYAGE DATA RECORDER

4.8.1 OVERVIEW

Voyage Data Recorders (VDR) record and securely store information concerning the position, movement, physical status, command and control of a ship. VDR equipment enables accident investigators to review the circumstances leading up to an incident, and helps to identify the cause(s).

Additionally, VDRs provide the Company with information that can enhance ship operation and management, and provide the owner/operator with a comprehensive record of events during a given period.

A simplified VDR (S-VDR)[12] is not required to store the same range of information as a VDR, but nonetheless records and securely stores information concerning the position, movement, physical status, command and control of a ship for use by accident investigators and owners.

12 All passenger ships and ships other than passenger ships of 3,000 gross tonnage and upwards are required to fit a VDR. Cargo ships of 3,000 gross tonnage and upwards built before 1 July 2002 may fit an S-VDR.

4.8.2 VDR REQUIREMENTS

A VDR is required to maintain a sequential record of information, covering at least a 48 hour period, which as a minimum should include:

VDR

- Date and time (UTC)
- Position, heading and speed
- Bridge audio
- Communications audio
- Radar and ARPA
- AIS

S-VDR

- ECDIS
- Echo sounder
- Main alarms
- Rudder order and response
- Engine and thruster order and response
- Hull opening, watertight door and fire door status
- Accelerations and hull stresses
- Wind speed and direction
- Roll motion
- Configuration data
- Electronic log book information

Any information or data source listed as being required to be recorded by a VDR should be recorded by an S-VDR if the data is available in an appropriate format.

4.8.3 PRESERVING RECORDS

Records should be retained for at least 30 days/720 hours on the VDR long term recording element, and at least 48 hours on its fixed and float-free recording element. After these times, older records on each of the recording elements may be overwritten with new data and will be lost. Watchkeeping officers should understand and be familiar with the procedures for preserving records as required by the SMS.

VDR and S-VDR recordings provide important information for marine accident investigators. All watchkeeping officers should be familiar with the procedures for preventing these records being overwritten.

4.8.4 VDR TESTING

The system should include functions to carry out a performance test at any time. Testing is required annually, and should always be carried out following repair or maintenance work to the VDR or to any source providing data to the VDR. This test may be conducted using the playback equipment and should ensure that all the required data items are being correctly recorded.

4.8.5 VDR PLAYBACK

Company policy relating to the playback of VDR data should be contained within the SMS. Playback of VDR data may provide a tool for analysing the performance of the Bridge Team.

4.9 ELECTRONIC POSITION FIXING SYSTEMS

Electronic position fixing systems provide an automatic and continuous position update for ships fitted with a suitable single or multi-system receiver.

4.9.1 GLOBAL NAVIGATION SATELLITE SYSTEM

A Global Navigation Satellite System (GNSS) is a satellite-based system that provides a means of obtaining continuous worldwide position, time and speed (over ground) information. There are two such systems available to ships which provide near global coverage:

- Global Positioning System (GPS) operated by the United States; and
- Global Navigation Satellite System (GLONASS) operated by the Russian Federation.

Beidou (China) has been recognised as a component of the World-Wide Radio Navigation System (WWRNS) and Galileo (Europe) is anticipated to achieve recognition in 2016. Both systems are expected to be fully functional in the near future. Other satellite systems may in future also be able to provide GNSS services.

4.9.2 DIFFERENTIAL GNSS

GNSS generally have a base accuracy in the order of 15-25 metres. Differential GNSS receivers offer greater navigational accuracy by applying corrections received from ground-based reference stations.

4.9.3 GNSS RECEIVERS

Whether as stand-alone equipment or as part of an integrated system, GNSS receivers provide:

- Position (including service quality information and geodetic datum corrections);
- Ground referenced course and speed; and
- Route storage and cross track distance (XTD) monitoring. By entering the passage plan into the GNSS receiver, the OOW has an independent method of monitoring the passage.

4.9.4 GEODETIC DATUM

A GNSS calculates positions referenced to a particular global geodetic datum. This may not be the same as the geodetic datum of the chart in use, with the result that the position when plotted is in the wrong place.

Where the difference or datum shift is known, a "satellite-derived positions" note on the chart provides the offset to apply to the position before it is plotted.

Many GNSS receivers have internal facilities to transform positions between different geodetic datums. This eliminates the need to apply datum offsets manually.

4.9.5 CHART ACCURACY AND PRECISION

ENC, RNC and paper charts are based on hydrographic surveys which are conducted using the best position-fixing technology available at the time. Although a ship navigating with GNSS may know its position to an accuracy of better than 10 metres, the positions of hazards and other objects on the seabed may only be known to an accuracy of 20 metres or less.

Paper charts show charted objects (including hazards) with a precision of approximately 0.3 mm (15 metres or more at scales of 1:50,000 or smaller). Due to the screen resolution of ECDIS, the precision of charted objects on ECDIS may not be substantially different from that of paper charts.

4.9.6 ALTERNATIVE POSITIONING SYSTEMS

Research projects continue to investigate the viability of independent terrestrial alternatives to GNSS which can provide positional information to ships in the event of a GNSS failure.

Although the use of hyperbolic positioning systems at sea has declined, some navigation authorities have developed eLoran, derived from Loran-C, in order to provide a suitable back-up to GNSS in areas with eLoran coverage.