ShipInsight

Trusted Information on Maritime Technology and Regulation

Navigation and Bridge 2 | November 2015

Regulation • e-navigation • Position Fixing
Radar and Sonar • Arctic Navigation • Signals and Sensors

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Introduction

Following on from Navigation and Bridge Pt 1 and ECDIS, this guide completes ShipInsight's coverage of the regulation and equipment covering the command centre of the ship although some elements such as Dynamic Positioning are covered in more depth in the Training & Simulation Guide. At the core of this guide are the key elements such as position fixing equipment and systems for increasing awareness of the navigating officers. Today GPS is the main means used for fixing position but there is a growing awareness that there needs to be a backup system available in case of failure and so there is re-awakened interest in the 21st century version of LORAN as well as recognition that older technology such as sextants should not be abandoned altogether.

There is no doubt that the technological advances in navigation have made life a great deal easier for navigators but there are traditionalists who say that they have also had a detrimental effect on the skills needed to navigate safely. Today it is AIS, ECDIS and GPS that is taking some flak but much the same was said in the 1950s when radar was first making its way onto ships' bridges.

While ECDIS permits ships to plan voyages in greater detail than was previously possible, it can only be fully effective if the ship's position can be pinpointed and floating and submerged obstacles identified. GPS has revolutionised navigation and is used also for providing evidence of compliance with MARPOL and SOLAS requirements such as emission controls and collision avoidance.

While technology can certainly facilitate safer and improved navigation over reliance on modern technology is a fault that few regulators can seem to avoid whether in shipping or in other industries. In Shipping its use has been embraced by regulators and forms the basis of what has become known as e-navigation – a concept that is still somewhat nebulous and subject to much debate with strong views expressed for and against.

As well as e-navigation, the proposed opening up of the Arctic looks to have implications for the future with improved radar and other technologies being developed to aid ice navigation.

Malcolm Latarche
Lead Editor

Contents

Lead Editor Malcolm Latarche
malcolm@shipinsight.com
Publisher Adam Foster
adam@shipinsight.com
Art Director Chris Caldwell
Advertising Steven Price
+44 (0)20 3096 2803
ShipInsight, 2A The Quadrant,
Epsom, Surrey, KT17 4RH, UK
Visit shipinsight.com

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ShipInsight

Chapter 1 *Regulation*

What SOLAS and other rules require on ships

MOST OF THE INTERNATIONAL REGULATIONS concerned with navigation on board vessels are found almost entirely within the text of SOLAS but there are both flag and port state elements that will also need to be investigated. Navigation as a subject is not covered by SOLAS until Chapter V and then most of the regulations are concerned with matters such as weather information, ice patrols, bridge layout, navigation warnings, hydrographic services, life-saving signals and ancillary equipment.

The ShipInsight Navigation & Bridge Guide Pt 1 deals in detail with the carriage requirements for ancillary systems such as VDR, AIS, BNWAS and the communication equipment required under GMDSS. Although there is some connection with the mandatory navigating equipment, the regulations for systems covered are not repeated in this guide.

The carriage requirements for the key navigation systems such as radar, compasses and tracking systems do not appear until regulation 19 where they are laid out in a way that deals firstly with all ships and then the additional requirements that come with increased ship size as measured in gross tonnage.

The divisions of ship type and size according to Chapter V Regulation 19 paragraph 2 are:

- *2.1 All ships, irrespective of size*
- *2.2 All ships of 150 gross tonnage and upwards and passenger ships irrespective of size*
- *2.3 All ships of 300 gross tonnage and upwards and passenger ships irrespective of size*
- *2.4 All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size. This section only covers AIS*
- *22.5 All ships of 500 gross tonnage and upwards (2.6 details some duplication requirements)*
- *22.7 All ships of 3,000 gross tonnage and upwards ShipInsight Regulation 456*
- *22.8 All ships of 10,000 gross tonnage and upwards*
- *22.9 All ships of 50,000 gross tonnage and upwards.*

In some instances alternative 'other means' are permitted for certain requirements. When "other means" are permitted under this regulation, they must be approved by the Administration (Flag state) in accordance with regulation 18. The navigational equipment and systems referred to in regulation 19 shall be so installed, tested and maintained as to minimise malfunction.

Navigational equipment and systems offering alternative modes of operation shall indicate the actual mode of use. Integrated bridge systems shall be so arranged that failure of one subsystem is brought to the immediate attention of the officer in charge of the navigational watch by audible and visual alarms and does not cause failure to any other subsystem. In case of failure in one part of an integrated navigational system, it shall be possible to operate each other individual item of equipment or part of the system separately.

Performance standards for the various systems are laid out in numerous IMO documents are subject to changes from time to time. When the performance standards change it is not normally necessary to replace equipment fitted prior to the change of date but in some cases, ECDIS is a good example, a change in the performance standards may necessitate an adaption to the equipment fitted. When a new system or piece of equipment is added to the mandatory carriage requirements because of new IMO regulations, there is often a rollout programme which will see different ship types and sizes affected over a period of time. The most recent example of bridge equipment affected by new performance standards is the VDR for which new standards came into effect in June 2014. Part of this was influenced by the requirement for electronic inclinometers to be interfaced to the VDR and which have also had new performance standards published in July 2013.

Performance standards for the various systems are laid out in numerous IMO documents are subject to changes from time to time.

Prior to that, changes to the regulations were mainly concerned with the introduction of AIS, LRIT and ECDIS and also the development of the e-navigation concept. E-navigation will be looked at in the following chapter but in the IMO's own words its work is to develop a strategic vision for e-navigation, to integrate existing and new navigational tools, in particular electronic tools, in an allembracing system that will contribute to enhanced navigational safety (with all the positive repercussions this will have on maritime safety overall and environmental protection) while simultaneously reducing the burden on the navigator.

The IMO says that as the basic technology for such an innovative step is already available, the challenge lies in ensuring the availability of all the other components of the system, including electronic navigational charts (Now in progress with the mandatory carriage of ECDIS), and in using it effectively in order to simplify, to the benefit of the mariner, the display of the occasional local navigational environment.

E-navigation would thus ShipInsight Regulation 457 incorporate new technologies in a structured way and ensure that their use is compliant with the various navigational communication technologies and services that are

already available, providing an overarching, accurate, secure and cost-effective system with the potential to provide global coverage for ships of all sizes.

Polar navigation rules now in place

The IMO's Polar Code which had been in development for several years is now a fact and its text has been distributed in RESOLUTION MSC.385(94) (adopted on 21 November 2014). As a consequence there will be a new chapter XIV of SOLAS that enters into force on 1 January 2017.

One of the requirements of the Polar Code is for ships affected by it to have a Polar Waters Operational Manual (PWOM). The structure and aims of the PWOM have their own section in the Polar Code but with particular regard to navigation matters such as passage planning and details of the limitations of any equipment must be included. It may be that much of this information is already included in the safety management system of vessels that frequent Polar Waters and in such cases the procedures and instructions can be easily incorporated into the PWOM.

For new vessels it will be necessary for the ship operator to devise a PWOM for the vessel perhaps using a template but bearing in mind that some information will be ship specific.

Although there is little in the Polar Code as regards additional navigational equipment there are requirements for certain additional items with a period allowed for retrofitting through to January 2018. Navigation with magnetic compasses at extreme latitudes has always been difficult due to the proximity of the magnetic poles in both hemispheres.

This is recognised within the Polar Code which requires all affected vessels to be equipped with two nonmagnetic compasses able to operate independently of each other.

This would seem to suggest the need for two gyro-compasses, but as German navigation specialist Raytheon points out 'very close to the North Pole, even the gyro compass loses some of its accuracy. The gyro error at Spitzbergen (80 degrees N) is 2.3 degrees; at a latitude of 85 degrees north (300 nm from the pole) the error is 5.6 degrees. In the new Polar Code, therefore, IMO requires that for travel in latitudes above 80 degrees N a satellite compass must be on hand as well'.

There is also new requirement for ice training. Previously many of the ice specialist working on ships that operated in ice-infested waters were well qualified by experience but with little if any formal recognition of their skills. This will need to change but since there is little likelihood of any immediate surge in the number of ships operating in ice, the pressure on the few specialist training courses that do exist will probably not be too great for them to cope.

Teamwork now a requirement

While it is the equipment that makes up the hardware of a ship's bridge, safety in navigation is as much about using the equipment properly and communicating with others both on the own bridge and on other vessels.

It is therefore not surprising that a large section of Chapter V of SOLAS is devoted to this sort of activity.

Most regulations governing crew numbers and duties are formulated by flag states although the competency of officers and ratings is governed by STCW. The latest version of STCW is the 2010 edition and although this came into force in 2012 there is a transitional period through to 2017 during which holders of existing certificates can continue to be covered by them before having to meet the new requirements.

Included in the 2010 version is a new requirement for bridge resource management for senior officers and leadership and management skills within their certificate.

Companies should be responsible for providing training in these areas where seafarers do not have appropriate training. Official casualty investigations frequently highlight the human factor as either the root cause or a contributory factor and consequently there is a movement within the industry to improve bridge team procedures and management. Under STCW 2010 Officers in charge of navigational watches must have knowledge of bridge resource management principles, including:

- *allocation, assignment, and prioritization of resources*
- *effective communication*
- *assertiveness and leadership*
- *obtaining and maintaining situational awareness*
- *consideration of team experience*

There are three means of demonstrating competence permitted and these are evidence of appropriate training, simulator training or approved in service experience. Beyond STCW and any flag state requirements there is no regulation currently that makes training in bridge team management compulsory because the requirement could be met by way of in service experience but failure to address known problems could be considered a non-compliance with a company's safety management system and may be picked up on by a PSC inspection.

All ships engaged on international voyages shall keep on board a record of navigational activities and incidents which are of importance to safety of navigation...

Under the IMO committee restructuring put in place in 2013, there is a new sub-committee reporting to the Maritime Safety Committee (MSC) that has taken over the role of developing regulation with regard to STCW and other codes and conventions. The Sub-Committee on Human Element, Training and Watchkeeping will address issues relating to human element training and watchkeeping, including minimum international standards for training and ShipInsight Regulation 459 certification of seafarers and fishing vessel personnel. It will also deal with technical and operational issues related to maritime safety, security, and environmental protection, to encourage a safety culture in all ship operations including the issue of safe manning. Other work covers the review, updating and revision of IMO model courses; and promotion and implementation of the IMO's human element strategy. The issue of safe manning is something that many believe requires an international regulation and should not be left to flag states to determine. This is a controversial issue and will be resisted by many flag states but a future rule change cannot be ruled out.

Working practices requirements are not all concerned with encouraging teamwork but address some more routine matters. Regulation 28 covers the requirements for maintaining the ship's log. The regulation states

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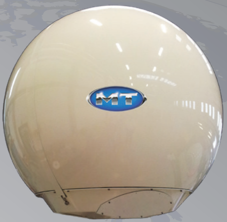

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that ‘All ships engaged on international voyages shall keep on board a record of navigational activities and incidents which are of importance to safety of navigation and which must contain sufficient detail to restore a complete record of the voyage, taking into account the recommendations adopted by the Organization’.

The recommendations referred to are contained in IMO Resolutions A.916(22). This regulation gives flag states the option to record the information in a different way than in the official logbook. Electronic logs are available from companies such as Kongsberg (K Log) and IB (Infoship ELB) among many others. These systems can automatically record speed and position at fixed intervals with other information being entered manually as required.

Not all flag states permit electronic logbooks and it should be borne in mind that Port State Control and other officials may at various times wish to inspect a ship’s log and difficulties could arise if information that they might expect to find in writing is missing. Regulation 28 also requires ships above 500gt engaged on international voyages exceeding 48 hours, to submit a daily report to its company giving position, course and speed and details of any external or internal conditions that are affecting the ship’s voyage or the normal safe operation of the ship.

This requirement is one that most sensible operators had in place long before it became an official requirement. The report may now be sent by automated means with many operators taking advantage of tracking services offered by specialist providers that also make the information available to charterers or, in the case of liner vessels, shippers and receivers.

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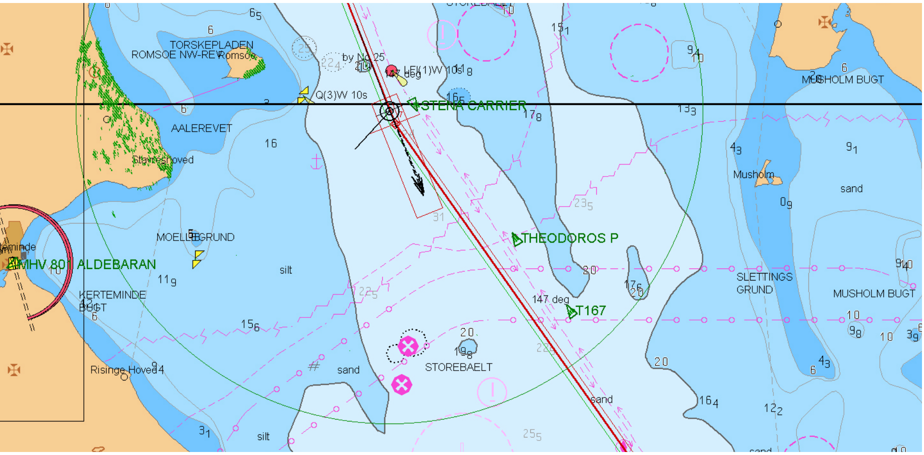
Chapter 2 *e-navigation*

Safety improvements and cutting costs in the computer age



E-NAVIGATION IS THE CURRENT HOT TOPIC in the navigation arena with proponents and regulators seeing it as a universal force for good that will among other things; improve safety, protect environments and enhance the commercial operation of ships and ports. Others view it with suspicion believing that there are ulterior motives behind its development and that there is little support for some of the declared aims of the various projects espousing it.

Before exploring the concept further it is necessary to look at the developments that have taken place in navigating technology and regulatory moves over the last two decades.

Modern ships are obliged to carry an extensive array of navigation and control systems and equipment on the bridge most of which have evolved at different periods in time over the past 60-70 years. The most recent system to have been mandated under SOLAS is ECDIS but it will still be some years before all vessels are required to be equipped.

Integrated options

As a consequence of the continual addition of new equipment, many ships have a bridge comprised of disparate stand-alone systems. On newer vessels it is possible to integrate systems so that two or more can share data or sensor input with most of the very latest vessels having integrated navigation systems (INS) or integrated bridge systems (IBS).

There is a deal of confusion over the difference between the two terms and many consider them interchangeable. The IMO however does have different definitions, an IBS is defined in Resolution MSC.64(67) and an INS in MSC.86(70). Comparing the definitions shows that an INS is a combination of navigational data and systems interconnected to enhance safe and efficient movement of the ship, whereas IBS inter-connects various other systems to increase the efficiency in overall management of the ship. More specifically, the IMO definition of an IBS applies to a system performing two or more operations from:

- *passage execution;*
- *communication;*
- *machinery control;*
- *Loading, discharging and cargo control and safety and security.*

By contrast the IMO defines three versions of an INS with each ascending category also having to meet the requirements of lower categories:

- *INS(A), that as a minimum provide the information of position, speed,*
- *heading and time, each clearly marked with an indication of integrity.*
- *INS(B), that automatically, continually and graphically indicates the ship's*
- *position, speed and heading and, where available, depth in relation to the*
- *planned route as well as to known and detected hazards.*
- *INS(C), that provides means to automatically control heading, track or speed*
- *and monitor the performance and status of these controls.*

The two definitions do not have a common requirement as to the navigation element so it cannot be said that an IBS is an extended INS although many consider this to be the case. The difference between the two is likely to disappear gradually as most shipowners are specifying high degrees of integration for new vessels in many cases going beyond that defined as an IBS. Both systems along with ECDIS are seen as being essential for the concept of e-navigation to be given a framework and direction.

e-navigation

There is as yet no requirement for a ship to be built with an integrated system but few if any ships today are built with anything else. The subject of bridge layout and ergonomics was covered in the ShipInsight Navigation & Bridge Guide Pt 1 as was the requirement to carry a VDR. Integrated systems and VDR have a common element in that both bring together data from disparate systems. In fact VDRs as opposed to simplified versions (S-VDRs) were made more possible by integrated systems than perhaps any other development in navigation technology or regulation.

There is no doubt that there are significant advantages for navigators from integrated systems since it is possible to monitor and use all systems and instruments from a single work station. In addition an integrated system with several work stations and screen confers a high degree of redundancy and system availability. The inclusion of ECDIS also permits passage -planning and chart work to be done on the main bridge as opposed to in the chart room.

Every major navigation system provider offers an integrated system of some description as well as offering stand-alone systems. The systems are sold under brand names and include SAM Electronic's NACOS, Kelvin Hughes' Manta Bridge, Sperry Marine's Vision Master, Raytheon Anschütz' Synapsis and Kongsberg's K-Master among many.

Defining e-navigation

Exactly what constitutes e-navigation is difficult to pin down. As far as the IMO is concerned it has its roots in the MSC(81) meeting in 2006 when a roadmap aiming for eventual implementation in 2013 was drawn up. By 2009 it had defined e-navigation as;

- ***E-navigation is the harmonised collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.***
- ***E-navigation is intended to meet present and future user needs through harmonisation of marine navigation systems and supporting shore services.***

Today the IMO is still discussing e-navigation with the latest developments described later in this chapter. However, the idea has much earlier

roots and could be traced back to the EU ATOMOS project begun in 1992. ATOMOS was an acronym for Advanced Technology for Optimizing Manpower on Ships, and its goal was simply to find ways to reduce manning on EU ships as a means of making them more competitive. At the time the EU felt that European shipping was losing out to Asian and Eastern European competitors who had lower wage costs and could therefore consistently undercut European operators. In the early 1990s it was wages and not fuel that constituted the greatest part of an owner's outlay.

The summary document of the first ATOMOS project (there were to be at least three more stages) contained the following conclusion:

> **In terms of significance, many of the ATOMOS results should prove to be of substantial value. It is no secret that competition in the shipping industry is increasing day by day, with European shipowners being under constant pressure from third-world owners, or owners operating under third-world flags. The developments in the Soviet Union has not eased the situation for the EU fleet.**

Much related to the issue of competition is the issue of maritime safety, however very often in reverse proportion. ATOMOS research has found that everything else equal, a low-manning ship equipped with ATOMOS technology is more competitive than a similar vessel equipped with conventional technology. A further finding of research is that modern, low-manned, high-tech ships are (at least) as safe as conventional ships. Many of the technologies looked into during the ATOMOS project shows great potential for an even further increase in maritime safety, an increase that could easily become mandatory, and an increase that might not be possible for vessels with conventional equipment.

Given the trends outlined very briefly above, and given any EU owner operating conventionally equipped vessels profitably today, the combined ATOMOS results indicates that competitiveness, safety and profits would increase by the utilisation of high-tech vessels.

While it may not be recorded in the ATOMOS documents, there was a belief that the project could eventually lead to unmanned ships being operated remotely by shipping companies and shore traffic controllers.

e-navigation

Perhaps realising that such a scenario was not going to be an easy sell, the project morphed in to something less revolutionary and aimed more at safer shipping. The first summary document contains hints at what the IMO would be asked to promote and which will be recognised as the core elements of e-navigation.

For example:- 'the aim was to develop and integrate voyage planning, track planning and navigation tools such as electronic seacharts and situation analysis in order to minimize manpower needs and operator workloads in the ship control center. The direct consequence of the research was expected to provide means for optimized voyage plans with respect to economy and safety, taking account of fuel consumption, weather, wave data and other information. Further, the track planning part of the system was expected to increase safety by providing decision support during close encounters with other vessels, based on the international rules for collision avoidance'. And 'work was undertaken with the objective of examining current approaches to the integration of navigation, cargo handling and the control and monitoring of machinery to allow them to be performed, under normal operational conditions, by one man at a centralized ship control station. By considering factors such as ergonomic layout, man/machine interfaces and the optimization of operating procedures, the aim of the task was to produce guidelines for the safe and efficient implementation of centralized ship control stations'.

It is interesting to note that the idea of unmanned ships has not gone away and between 2012 and 2015 the EU funded the Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project which according to the official description had the specific tasks to:

- ***Develop the technology concept needed to implement the autonomous and unmanned ship.***
- ***Develop the critical integration mechanisms, including the ICT architecture and the cooperative procedural specifications, which ensure that the technology works seamlessly enabling safe and efficient implementation of autonomy.***
- ***Verify and validate the concept through tests runs in a range of scenarios and critical situations.***
- ***Document and show how this technology, together with new and more***

centralized operational principles gives direct benefits for non-autonomous ships, e.g., in reduced off-hire due to fewer unexpected technical problems etc.

- *Document how legislation and commercial contracts need to be changed to allow for autonomous and unmanned ships.*
- *Provide an in-depth economic, safety and legal assessment showing how the MUNIN results will impact European shipping competitiveness and safety.*

Further MUNIN's results will provide efficiency, safety and sustainability advantages for existing vessels in short term, without necessitating the use of autonomous ships. This includes e.g. environmental optimization, new maintenance and operational concepts as well as improved bridge applications. It is clear that the EU is determined to follow through on the original intentions of the ATOMOS projects but there does not appear to be much international interest in the idea.

It is interesting to note that the idea of unmanned ships has not gone away...

In the summer of 2015 a new project was announced to be led by Rolls-Royce. The Advanced Autonomous Waterborne Applications Initiative will produce the specification and preliminary designs for the next generation of advanced ship solutions.

The project is funded to the tune of some €6.6Mn by Tekes (Finnish Funding Agency for Technology and Innovation) and will bring together universities, ship designers, equipment manufacturers, and classification societies to explore the economic, social, legal, regulatory and technological factors which need to be addressed to make autonomous ships a reality. The project will run until the end of 2017 and it aims are to pave the way for solutions - designed to validate the project's research.

Although an autonomous ships is already technically feasible, their use would not currently be permitted for anything but domestic operation and even then there would likely be problems with commercial support.

e-navigation

Implementing e-navigation

At NAV 59 in September 2013 the IMO re-established a Correspondence Group on e-navigation under the coordination of Norway. The group included many flag states and industry bodies along with organisations such as the IHO and IMSO. The terms of reference of the group for those interested in further research are set out in document NAV 59/20, paragraph 6.37.

The Correspondence Group completed a report in March2014 which was discussed at the inaugural meeting of the IMO's Sub-Committee on Navigation, Communications and Search and Rescue (NCSR) in July 2014 and passed to the MSC meeting in November 2014.

The report contained an e-navigation Strategy Implementation Plan (SIP) which can be accessed at the Norwegian Coast Guard website. The SIP sets up a list of tasks and specific timelines for the implementation of 'prioritised e-navigation solutions' during the period 2015-2019. Several 'solutions' are included in the SIP of which five have been prioritised. Using the numbering given in the plan, the five prioritised solutions are:-

- ***S1: improved, harmonized and user friendly bridge design;***
- ***S2: means for standardized and automated reporting;***
- ***S3: improved reliability, resilience and integrity of bridge • equipment and navigation information;***
- ***S4: integration and presentation of available information in graphical displays received via communications equipment; and***
- ***S9: improved communication of VTS Service Portfolio.***

Apparently S1, S3 and S4 address the equipment and its use on the ship, while S2 and S9 address improved communications between ships and ship to shore and shore to ship.

It is quite possible that the SIP will be revised over time but its existence now provides a structural framework in which further developments are likely to take place and also gives those involved in developing and using the technology needed to realise e-navigation further information to work with.

At MSC95 in July 2015 it was decided that further work should be carried out on e-navigation with any likely developments coming in 2017 at the earliest. In particular the meeting approved the document Guideline on Software Quality Assurance and Human-Centred Design for e-navigation which has been issued as MSC.1/Circ.1512.

Other work related to e-navigation put in train at MSC95 includes:

- *Revised performance standards for Integrated Navigation Systems (INS) – it was agreed to review resolution MSC.252(83) relating to the harmonization of bridge design and display information. The MSC agreed to include this output in the 2016-2017 biennial agenda of the NCSR and in the provisional agenda for NCSR 3 with a target completion year of 2017;*
- *Guidelines and criteria for ship reporting systems – it was agreed to review resolution MSC.43(64), as amended, relating to standardization and harmonized electronic ship reporting and automated collection of on-board data for reporting. The MSC agreed to include this output in the 2016-2017 biennial agenda of the NCSR and provisional agenda for NCSR 3 with a target completion year 2017;*
- *General requirements for ship-borne radio equipment forming part of the GMDSS and for electronic navigational aids – it was agreed to revise Resolution A.694(17) relating to Built In Integrity Testing (BIIT) for navigation equipment. The MSC agreed to include this output in the post-biennial agenda (2018-2019) of the MSC with NCSR assigned as the coordinating body; and*
- *Guidelines for the harmonized display of navigation information received via communications equipment – it was agreed to include this output in the 2016-2017 biennial agenda for the NCSR and the provisional agenda for NCSR 3 with a target completion year of 2017.*

The second of the above items has been given high priority by several parties because it is aimed at relieving the burden on ships officers of completing customs, immigration and other forms and providing information on cargo manifests and hazardous cargo.

That must be a puzzling development to many port agents who routinely compile that information well in advance of a vessel's arrival and merely require the addition of a signature and ships stamp on arrival. The signing and stamping of documents usually takes just a few moments during the agent's visit which will still be necessary to deliver cash, spares, mail etc. The IMO's concept of e-navigation is not shared by all and interest in Apps for mobile computing systems is growing. Whether this is a trend that will continue is debateable. Some of the Apps do appear to have attracted devotees but unless there is a regulation that mandates the use of any Apps, the fact that they will not be universally adopted means that they could adversely affect safety under many circumstances.

It has been suggested that e-navigation would reduce the cost of maintaining existing aids to navigation. The argument for this is hard to justify because it would seem to imply that buoys and lights could be abandoned. Although that would be possible with the aids to navigation becoming merely items of data in an ENC, the consequences of a failure of satellite positioning systems or the onboard ECDIS would effectively leave the crew of a ship underway in restricted waters blind to all hazards and with no way of avoiding them short of their own experience and knowledge.

Just as with the use of existing navigational aids in the days before they were mandated, few can doubt that Apps will inevitably find their way on the bridges of some vessels. Their use restricted to the navigators' own ships will not necessarily be contentious unless an incident results but where Apps are designed to interact with other ships the question of safety is paramount. There are a very small number of Apps either in use of under development designed to be interactive with other ships. Some have even suggested that such apps could make ColRegs redundant as ships' systems will be able to calculate and carry out appropriate manoeuvres. Such a use would almost certainly be resisted by navigators and regulators alike because the manoeuvres chosen would not be predictable or even understandable to other vessels nearby that were not under the control of a similar App. Whatever direction e-navigation does take, one thing that is certain is that national governments and bodies such as the IMO can only regulate for systems that are available and few national governments are in the position to invest much in the way of financial resources. For ship operators, the need to fit equipment and comply with the rules is a cost they will have to swallow and if after that they find they have any reserves left it does not preclude them from using any other systems that developers may choose to market. Away from the immediate needs of navigation, the accepted 'official' idea of e-navigation pre-supposes acceptance by operators, port facilities and cargo interests.

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Chapter 3 *Position Fixing*

Technology from past present and future all have their place

AT THE OUTSET OF EVERY VOYAGE, navigators can be quite certain of where their ship is but once beyond visible landmarks this is not so easy. Without knowing the exact position navigation is impossible beyond sailing in a general direction. Accurate navigation requires a means of determining a ship's exact position and direction at all times and under all conditions.

In times past this would have been dependent upon a magnetic compass and a sextant. Both instruments have limitations but skilled navigators have been using them successfully for centuries before and after the invention of alternatives such as the gyro compass and GPS.

There is still a requirement under SOLAS for a ship to have a magnetic compass but there is no longer a mention of a sextant. There is however a requirement under STCW for navigators to be able to perform celestial navigation which would most definitely involve the use of a sextant. Many navigators and some ship operators will ensure that a sextant is available on board for use in emergencies such as a power failure which would take out the gyro compass and the GPS, or a loss of the GPS signal which could result from jamming or GPS satellite malfunctions.

A magnetic compass is of course only able to indicate magnetic North which is not a fixed point in any case and local geomagnetic conditions can cause it to be in error as can the metallic structure of the ship itself (especially if there have been changes to the superstructure or after drydockings) or the cargo the ship is carrying. The strength of the earth's magnetic field has reduced noticeably in recent times and the movement of the magnetic north pole has accelerated. It is even considered possible that the earth's magnetic core could flip reversing its natural polarity making magnetic compasses point South instead of North.

There is still a requirement under SOLAS for a ship to have a magnetic compass but there is no longer a mention of a sextant.

Even without natural changes, over time the accuracy of a magnetic compass will deviate and it will be necessary to correct the compass and record the deviation. This is done by a process known as swinging the ship which should be carried out in open water at regular intervals. The compass is checked using a reference point such as the sun or a visible landmark on a known bearing. Deviations will be checked with the ship on all eight of the main headings and corrections made by repositioning the corrective elements that are located around the binnacle.

The compass card is isolated from movement as much as possible by suspending the card on a jewelled mounting and in a liquid filled housing. Both of the damping means can become defective, the mounting by wear and the fluid by leakage or appearance of air bubbles.

Tests can be done using a magnet to deflect the card through 90º and then releasing it and timing how long before the card returns to showing North. If the time is excessive, the compass may need to be calibrated or repaired.

All vessels should have their compass swung/adjusted and a new deviation card issued at maximum two yearly intervals. When a new vessel is commissioned, compass deviation on any heading should be no more than 3°. Thereafter, deviation on any heading should be 5° or less.

Vessels transiting the Panama Canal are required by the canal authorities to have had a valid compass deviation card issued within the previous 12 months. Some flag states and many shipowners will stipulate that the magnetic compass is to be swung and adjusted annually.

The limitations of the magnetic compass were a driving factor for the development of the Gyro compass in the early years of the 20th Century. Invention of the device is usually credited to Raytheon Anschutz but there were earlier variants in its evolution. A gyro compass makes use of gyroscopic principals and the earth's rotation to give a bearing that remains aligned to true North once the initial heading is set and the gyro put in motion. Unlike a magnetic compass, the gyro compass is not hampered by external magnetic fields but can be affected by rapid changes in the orientation and attitude of the ship.

Ships that are not obliged to carry a gyro compass are required to have a transmitting heading device (THD) that shows the ship's true heading.

Before the advent of GPS, a magnetic compass would be used to set the gyro compass to the correct heading. On most modern ships the GPS or other navigational aids feed data to the gyrocompass allowing a small computer to apply a correction. Alternatively a design based on an orthogonal triad of fibre optic gyroscope or ring laser gyroscopes will eliminate these errors, as they do not depend upon mechanical parts.

The fibre optic gyrocompass is a complete unit, which unlike a conventional compass, has no rotating or other moving parts. It uses a series of fibre optic gyroscope sensors and computers to locate north. It has very high reliability and requires little maintenance during its service life. The system usually includes a sensor unit, a control and display unit, and an interface and power supply unit. It is often linked with the ship's other navigational devices including GPS.

The gyro compass does not need to display the heading mechanically on a single display because it uses a sensor and the information can be sent to repeater units which would be located at the steering station, in the emergency steering room and on the bridge wings. The exact number and location of repeaters is governed by SOLAS and will depend upon the size of the vessel.

Although a gyro compass is unaffected by the magnetic interference from the ship or surrounding equipment, it is reliant on a stabilised power source and in some instances on a GPS input to remain functioning.

Navigation in the satellite era

Before the advent of satellite navigation systems, most vessels were required by SOLAS to be equipped with a radio direction finder (RDF) for determining exact position at sea. RDF systems such as Decca Navigator and LORAN-C make use of radio signals transmitted from a series of shore-based radio stations. The signals would be on different frequencies allowing triangulation to be used when two or more (preferably three) signals were received and identified by the equipment on board ship.

Unlike the satellite systems that replaced them, RDF technology was not available outside of the radio range of the transmitters. However, since precise location and direction is needed most during approach to land and ports this was not a major shortcoming, except perhaps for giving the vessel's position during emergencies.

The requirement to install RDF systems was dropped from SOLAS at the turn of the century but there are moves to re-instate the technology as a standby in case of satellite system malfunctions. Satellite navigation has caused a revolution in marine navigation and feeds in to so many modern systems including ECDIS, AIS and the latest gyro compasses. It is also an essential technology in making dynamic position possible. The most commonly used satellite system is GPS but there are alternatives. Currently the only functioning alternative is the Russian GLONASS system with the European Galileo system due to come on stream in the near future and the Chinese BeiDou system expected to be operational throughout Asia in 2018 and globally by 2020. Ships that are not obliged to carry a gyro compass are required to have a transmitting heading device (THD) that shows the ship's true heading. Most THDs in use today are commonly known as a GPS Compass and make use of an antenna with two or three

GPS sensors. Where there are two they will be placed one either side of the vessel's centre line and at equidistance from it so as to be able to calculate the orientation of the vessel. The sensors can also be used to calculate pitch and roll or trim.

Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy, from the 15-meter nominal GPS accuracy to about 10 cm in case of the best implementations. DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions.

The first reference stations were established by US and Canadian authorities but a number of commercial DGPS services are now available.

These services sell their signal (or receivers for it) to users who require better accuracy than GPS offers. Almost all commercial GPS units, even hand-held units, now offer DGPS data inputs. GPS is controlled by the US military and although it is currently made freely available, the system can be turned off or its accuracy degraded is determined by the US authorities. The system is also not immune from jamming and atmospheric interference.

The issue of jamming has become very topical with the discovery that readily available $10 gadgets can be used to disrupt the GPS system over localised areas. So far there has not been an example of this being done maliciously but the possibility cannot be ruled out. More of a danger to the safety of navigation is the fact that solar flares and mass corona ejections could knock out many of the satellites needed for GPS and other systems to function. In recognition of the potential problems with GPS some countries are re-introducing an improved LORAN system. Enhanced Long Range Navigation (eLORAN), is the next generation of LORAN and has a reported accuracy near that of conventional GPS positioning in coastwise and harbour applications, and uses the infrastructure that is already in place.

Its effectiveness is a result of solid-state transmitters, advanced software applications and uninterruptible power sources, along with a new generation of shipboard receivers. Because the signal is much more powerful than GPS, eLORAN is not nearly as susceptible to jamming.

In early 2013, The General Lighthouse Authorities of the UK and Ireland (GLA) announced that ships in the Port of Dover, its approaches

and part of the Dover Strait can now use eLORAN technology as a backup to GPS. The ground based eLORAN system provides alternative position and timing signals for improved navigational safety. The Dover area, the world's busiest shipping lane, was the first in the world to achieve this initial operational capability. The Dover transmitter is the first of up to seven installations to be implemented along the East Coast of the United Kingdom. The Thames Estuary and approaches up to Tilbury, the Humber Estuary and approaches, and the ports of Middlesbrough, Grangemouth and Aberdeen will all benefit from new installations, and the prototype service at Harwich and Felixstowe will be upgraded. The GLAs' strategy is to extend their current trials and to continue building a European consensus in favour of eLORAN and to prepare for the introduction of eLORAN services in 2018.

Regular jamming of GPS signals by North Korea is alleged by the government in South Korea prompting the South Korean government to implement an eLORAN system.

In the Netherlands, a local company Reelektronika has, on request of the Dutch Pilots Corporation, developed and successfully tested Enhanced Differential Loran (eDLoran) to backup. The company said in January 2014 an accuracy of 5 metres was achieved at sea and in the Rotterdam Europort harbour area. A complete test system has been implemented which includes the eDLoran reference station and the eDLoran receiver for the pilots. This small and lightweight receiver can link using wi-fi with the standard software of the pilot's GPS-RTK equipment.

eLORAN development is not confined to Europe. The US has most of the infrastructure in place to initiate it without much delay and Russia and China also have LORAN systems that can be upgraded. In fact in December 2014 the US Department of Defense (DoD) decided to investigate future possibilities and in January 2015 invited tenders for possible supply of some 50,000 eLORAN receivers. The DoD is looking at both stand-alone eLORAN receivers and receivers that integrate eLORAN and GPS. More specifically they are looking for data on the size, weight, power, and cost of eLORAN receivers designed for maritime, aviation, vehicular, and timing applications.

In June 2015 a US Coast Guard Loran mast in Wildwood NJ was reactivated for a year-long demonstration and research eLORAN project. The signal is receivable at distances of up to 1,000 miles. As well as maritime uses, the US believes that eLORAN can provide navigation for drones in its airspace.

The project involves two engineering companies, UrsaNav, a supplier of eLORAN technology, equipment, and services, and Harris (which recently acquired Exelis), provide funding and technology for the tests supported by the USCG, Department of Defense, Department of Homeland Security and other federal agencies under a Cooperative Research and Development Agreement.

Elsewhere, regular jamming of GPS signals by North Korea is alleged by the government in South Korea. Last year it was announced that this has prompted the South Korean government to implement an eLORAN system that will cover the entire country by 2016. Plans for the alternative and backup system were described for the first time at an international forum in a paper presented in April 2013 at the European Navigation Conference (ENC) in Vienna, Austria.

The goal of the South Korean system is to provide better than 20-metre positioning and navigation accuracy over the country. Initial operational capability is expected in 2016 with final operational capability expected two years later. The South Korean government hopes to expand coverage to the entire Northeast Asia in close collaboration with Russia and China in the near future.

Chapter 4 *FURUNO*

Integrated Navigation Systems are much more than hardware

FURUNO HAS BEEN SUPPLYING INS SYSTEMS to the maritime industry for almost two decades and has gained a lot of experience in the field. Over the years FURUNO has refined the software and hardware to improve on performance and functionality. But INS is not just equipment – it relates to the everyday tasks performed by the navigators and has to reflect this in operation and features. It has to help provide a good situation awareness to the user and to support the user in decision making. This means that the user interface has to be simplified and the presentation of data and information is balanced between what is possible and what is needed. It requires that the systems can be supplied and maintained in a proper way for optimal uptime and reliability and that the manufacturer plays an important role in the end user education.

When the new FURUNO INS called FURUNO VOYAGER was developed, many new steps were taken some of which were new to the market. FURUNO decided to base the INS elements on LINUX operating system. This way the software was less vulnerable to updates and termination of commercial operating systems by their manufacturers, giving a possibly longer lifetime to the software and the platform.

The user interface was developed and afterwards evaluated by navigators operating different ships in different countries to gain a more intuitive user interface making the daily operation and task easier. The evaluation included hands on operation by navigators. While they were performing different tasks, their experiences and impressions were recorded to reveal possible inconveniences in the user interface. After the hands on operation, the navigators were interviewed to obtain more in depth understanding on how to improve the user interface.

At the same time FURUNO came up with the special Task Based Operation (TBO), which simplifies the user interface very much by limiting the tools and menus to only support the task at hand. The operator selects the task to be performed, for example route planning, chart management or route monitoring. As soon as the task has been selected, the instant access bar changes its look and displays the tools and functions relevant to the selected task. This is still a unique feature of FURUNO ECDIS.

By including end users' evaluation in the development phase, FURUNO gained much improved user interface and better understanding of the tasks performed by the navigators in their daily jobs. The gap between manufacturer and end users was narrowed by these activities, and the benefits for both parties are evident.

By redesigning the complete platform, FURUNO could improve on the performance, and the seamless zoom is an example of how this has greatly improved performance. The chart engine inside the FURUNO ECDIS and Chart Radar has been redeveloped and optimised, and the performance improvement is well established. When zooming in and out, the new chart engine manages to open the charts faster than the zoom is performed, which means that the operator does not have to experience that the system pauses while waiting for the charts underneath to be opened. Many such improvements have been accomplished thanks to the complete redesign. Since FURUNO is operating its own chart engine, which supports PRIMAR, UKHO and Jeppesen charts, it allows a high degree of flexibility for the ship owner, when the ship owner decides to change chart supplier. Because the chart engine is not optimised to only one chart supplier, there is no loss of performance when switching between suppliers.

The new ECDIS and Radar processors are equipped with eight RS-422 (NMEA) ports making it possible to install the units without additional interface units. In cases when the navigation system is more complex due to class requirements such as in high notation bridge designs, additional interface units can be added. The new generation INS comes with three LAN networks, which provides a high degree of duplication and fall back in case of failures and helps to ensure a safe operation even if a unit or one of the networks fails.

Because the INS cannot live isolated from the rest of the world and because the contact to the outside world also generates risks in terms of viruses and other malign threats, FURUNO has developed the Gate-1 communication unit with an external data infrastructure to ensure safe and reliable data exchange at low cost. The Gate-1 is a small communication processor, which allows for the exchange of data between the INS and the outside world. It is connecting to a network of FURUNO operated servers around the world which can identify the unit when called up.

When the ship has Internet access, the Gate-1 will call up the closest server and announce its presence based on its GPS position. The server validates the identity of the Gate-1 unit and checks if there are any chart updates or similar pending to be transmitted to the ship. If this is the case, a slow background transmission of data is initiated at a speed almost unnoticeable to the ship's crew. Even if it is a large amount of data, the Gate-1 ensures that the data is only streamed at low speed allowing the crew to utilise the Internet without any saturation from the data transfer. When the transmission is finished, the Gate-1 signs off and the servers are updated with information about the data, which has been transferred. In case the system is interrupted while transmitting data, a bookmark is inserted, and next time there is a connection, the Gate-1 will search for the bookmark and start downloading from there. This way already received data do not have to be retransmitted. In addition to the main navigation equipment, FURUNO provides a suite of products including GPS, AIS, speed log, echo sounder, satellite compasses, satellite communication systems, GMDSS, ice and oil detection radar systems. With an experience from developing and manufacturing navigation and communication equipment for almost 70 years, FURUNO has proven to be able to challenge new technologies and new design methods to optimise the performance and reliability of the products. Through the years FURUNO has built up the service and sales organisation providing service and maintenance globally through local representation. It has been a key point to FURUNO, that the high level of quality and reliability which is imbedded in the products is also reflected by the sales and service organisation.

To support the end users as much as possible, FURUNO has established its own end user training solutions. Very early FURUNO realised, that manufacturers have to take responsibility and provide support to the end users through good training services. In addition to the class room training, FURUNO has developed 2 distant learning systems, the NavSkills CAT and CBT. The NavSkills CAT was launched in July 2012. Today the system is operated in more than 100 locatiosn around the world and more than 250 workstations are in operation. FURUNO is currently the only manufacturer offering Computer Aided Training in parallel with Computer Based Training.

This means that the user interface has to be simplified and the presentation of data and information is balanced between what is possible and what is needed.

FURUNO will continue to contribute to the maritime industry through the current products and services and the future technologies that lies ahead. At this moment FURUNO is involved in several e-navigation projects as a partner challenging new approaches to ship operation and technologies.

To balance the technology drive FURUNO makes efforts to contribute to support the end user and assist them in having the best possible overview and situation awareness and making the right decisions. It has often been said that a majority of accidents are caused by the human factors. This may be true, but the avoidance of accidents has also been caused by the human factors. It is the task of the manufacturer to support the human factors to continue to avoid accidents.

COMPANY	BAMS	BNWAS	VDR	AIS	ECDIS	IBS
AC ANTENNAS				●		
ALPHATRON MARINE	●	●	●	●	●	●
AMI MARINE (U.K.) LTD		●	●			
COBHAM SATCOM (SAILOR)				●		
COMET						
CONSILIUM AB			●	●	●	●
DANELEC MARINE A/S			●		●	
DANIAMANT ELECTRONICS A/S	●					
FURUNO		●	●	●	●	●
INTERSCHALT MARITIME SYSTEMS AG	●	●	●		●	
JEPPESEN					●	
JOTRON			●	●		
JRC (JAPAN RADIO CO. LTD)	●	●	●	●	●	●
KELVIN HUGHES			●		●	●
KONGSBERG MARITIME		●	●	●	●	●
MARTEK-MARINE LTD		●			●	
MCMURDO MARINE		●		●		
NAVICO (SIMRAD BRAND)		●	●		●	
NAVIS ENGINEERING						
NAVITRON SYSTEMS LTD		●				
NETWAVE			●			
NORTHROP GRUMMAN SPERRY MARINE		●	●		●	●
PAINS WESSEX						
QINGDAO HEADWAY TECHNOLOGY CO.		●			●	
RAYTHEON ANSCHÜETZ	●	●	●	●	●	●
RH MARINE	●	●	●	●	●	●
ROLLS-ROYCE	●	●	●	●	●	●
RUTTER INC.						
SEAB MARINE		●				
SELMA CONTROL		●	●			
SERVOWATCH		●			●	
SM ELECTRICS	●	●				
THOMAS GUNN		●			●	
TOTEM PLUS	●	●	●		●	
TRANSAS		●	●	●	●	●
ULSTEIN	●					
VARD	●	●				●
WÄRTSILÄ SAM ELECTRONICS		●	●	●	●	●

RADAR	CHART RADAR	ARPA	GMDSS	SONAR	SIGNALS	ICE RADAR	DP
			●				
●	●	●	●	●	●		●
			●				
					●		
●	●	●		●		●	
●	●	●	●	●		●	
			●				
●	●	●	●	●			
●	●	●	●			●	
●	●	●		●		●	●
			●				
	●	●				●	
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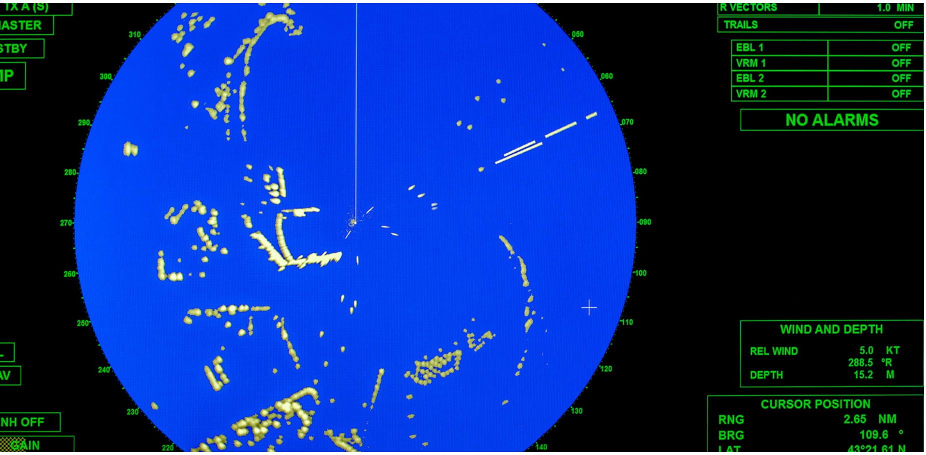
Chapter 5 *Radar and Sonar*

Electronic eyes and ears keep navigators aware



R VECTORS 1.0 MIN
TRAILS OFF
EBL 1 OFF
VRM 1 OFF
EBL 2 OFF
VRM 2 OFF
NO ALARMS
WIND AND DEPTH
REL WIND 5.0 KT
288.5 °R
DEPTH 15.2 M
CURSOR POSITION
RNG 2.65 NM
BRG 109.6 °
LAT 43°21.61 N

RADAR AND SONAR ARE BOTH EARLY EXAMPLES of modern navigation aids but their use in safe navigation has not diminished over time. While both can still be used as stand-alone systems they can also be integrated with more modern technologies.

Radar stands for RAdio Detection And Ranging an acronym composed by US military during WWII but the development dates back to the same era as gyro compasses. A radar set simply transmits a radio signal and receives its echo bounced off ships and other structures both natural and man-made. From the transmitted and received signals it is possible to determine the position and distance of the targets.

Radar was first used on merchant ships in 1946 and initially mostly by ferries allowing them to continue to operate safely in fog and at night. In 1960 recommendations for the use of radar were formulated for inclusion in the collision regulations. Later in 1974 with the new SOLAS convention, radar was made mandatory on ships in a rollout programme starting in 1980 and completing as surprisingly recently as 2002.

All passenger ships and other ships above 300gt are obliged to carry at least one radar system operating on the X-band and ships over 3,000gt are required also to carry a second radar operating in the S-band. The radar systems installed can be stand-alone systems or they can be systems that connect to other navigation systems in an integrated system.

Considering the length of time that radar has been used on merchant ships and that use of radar forms part of the competencies required of navigators under STCW, its improper use has been cited in many official investigations as the root cause of collisions and groundings. Most criticisms centre on mistakes in plotting and identification of targets.

It was to help with this that AIS was made mandatory (See ShipInsight Nav & Bridge Guide pt1) and as part of the introduction of AIS and the move to increasing use of electronic navigation, electronic plotting was also mandated. Ships built before 1 July 2002 are subject to slightly different regulations with regard to how the movement of targets on the radar display can be plotted. For system fitted the 1 July 2002 radars must be equipped with plotting aids, the type of which depends upon the size of ship.

Electronic Plotting Aid (EPA)

EPA equipment enables electronic plotting of at least 10 targets, but without automatic tracking (Ships between 300 and 500gt)

Automatic Tracking Aid (ATA)

ATA equipment enables manual acquisition and automatic tracking and display of at least 10 targets (Ships over 500 gt). On ships of 3,000 gt and over the second radar must also be equipped with an ATA, the two ATAs must be functionally independent of each other.

Automatic Radar Plotting Aid (ARPA)

ARPA equipment provides for manual or automatic acquisition of targets and the automatic tracking and display of all relevant target information for at least 20 targets for anti-collision decision making. It also enables trial manoeuvre to be executed (Ships of 10,000 gt and over). The second radar must incorporate ATA if not ARPA.

To estimate risk of collision with another vessel the closest point of approach (CPA) must be established. Choice of appropriate avoiding action is facilitated by the knowledge of the other vessel's track using the manual or automatic plotting methods. The accuracy of the plot, however obtained, depends upon accurate measurement of own ship's track during the plotting interval.

An inaccurate compass heading or speed input will reduce the accuracy of true vectors when using ARPA or ATA. This is particularly important with targets on near-reciprocal courses where a slight error in own-ship's data may lead to a dangerous interpretation of the target vessel's true track. The apparent precision of digital read-outs should be treated with caution.

Electronic plotting will not detect any alteration of a target's course or speed immediately and therefore should also be monitored constantly using all methods available especially visual contact through the bridge window. If two radars are fitted (mandatory for ships of 3,000gt and over) it is good practice, especially in restricted visibility or in congested waters, for one to be designated for anti-collision work, while the other is used to assist navigation. If only one of the radars is fitted with ARPA then this should be the one used for anti-collision work and the other for navigation.

Because the radar display is produced electronically from the signals generated by the system, it was always going to be an essential component of e-Navigation and integrated systems. Radar can be integrated with ECDIS or be used in a less sophisticated chart radar configuration. The chart overlays of a chart radar may have a limited amount of data and are not the equivalent to an Electronic Navigational Chart (ENC) used in the ECDIS or paper charts. Unlike the ECDIS, they should not therefore be used as the primary basis for navigation.

The bigger picture

No one would argue that the migration to wide screen displays as used in integrated systems has taken radar to a new level compared with the original cathode ray tubes but future improvements and enhancements promise to add more value and functionality. The next chapter will cover some of the developments with radar and other technologies that are showing great potential for Arctic navigation. Moving away from the monochrome cathode ray tube display to modern screen displays also allows the use of a wider colour palette to differentiate between systems and targets. As an example Kelvin Hughes introduced a feature called Enhanced Target Detection (ETD) mode, which it added to its Manta Digital range.

ETD enhances the display of slow-moving or stationary targets without interfering with the normal radar appearance or controls by treating static returns in a different way from moving returns and displays the moving ones in a different colour. Other added value systems include oil spill radar and small target radar that can identify very small targets in rough seas and have radar that can accurately determine dominant wave length, direction and period, significant wave height and superficial currents and send the data to systems for use in navigation support and safety measures. Oil spill radar is not a navigational requirement but its use in offshore oil production and anti-pollution activities means it is carried on many ships working in those sectors.

Under sea eyes

Radar may give ships the ability to ‘see’ other ships and fixed and floating objects at and above sea level but it is equally important for vessels to stay in water deep enough to keep afloat and avoid running aground.

All passenger vessels and other ships above 300gt are required to be fitted with an echo sounder which uses sonar to measure the depth beneath the ship. The IMO performance standards require a range from 2m – 200m and the ability to use two different scales; one for shallow waters to 20m and a second for deeper waters.

The echo sounder must be capable of giving an alarm when a pre-determined minimum depth is encountered. Data must be recorded and at least the previous 12 hours of information recorded and be available. Older echo sounders recorded the information on paper rolls and this is still a permitted method. Newer more advanced models make use of electronic recording and also take positional input from a GPS. The display on a newer model will generally be in colour on a small LCD screen. In common with other modern equipment, echo sounders often have features that exceed the IMO requirements.

There is a potential conflict between sonar and ECDIS where the data included in ENCs covers depth information. Using ECDIS for passage planning involves entering a ships draught and setting alarm parameters.

Just as with paper charts there is potential for the depths recorded in ENCs to be inaccurate and it may be necessary to deviate from the passage plan if the sonar reports a difference in the ENC data and the actual under keel depth.

Chapter 6 *Arctic Navigation*

Preparing to open up polar waters

COMMERCIAL SHIPPING AND OIL AND GAS operations in Arctic waters have been expected to increase in the near future although recent events in the geo-political arena, the falling price of crude oil and a slowdown in world trade looks likely to delay any major growth in Arctic operations in the short to medium term and possibly longer.

Ships have always navigated through ice-infested waters but the conditions found in the Baltic, Black Sea and other areas that freeze although harsh and damaging to ships are quite benign compared to conditions nearer the poles. The interest shown in Polar navigation has led the IMO to undertake the development of a Polar Code that places new requirements on ships operating in such regions. As part of the work, the IMO has adopted guidelines for ships which although currently voluntary unless decreed otherwise by a flag state are the basis for the new Polar Code which has now been adopted and comes into effect for new vessels on 1 January 2017 and for existing ships a year after that.

The Polar Code is less extensive in many ways than the earlier guidelines with three chapters (9-11) covering navigation related aspects including equipment, communications and procedures. With regard to functionality of equipment and the type almost nothing is said in the code leaving the guidelines as the most comprehensive source of information.

The guidelines are laid out in IMO document A 26/Res.1024 GUIDELINES FOR SHIPS OPERATING IN POLAR WATERS. The document was published in March 2010 and flag states have been 'invited' to apply it to ships built after January 2011 and 'encouraged' to apply it to older vessels as far as practical.

The guidelines cover a number of areas with Chapters 1 and 12 (reproduced below) being of particular interest to those involved in navigation.

Chapter 1 deals with the requirement for special ice navigators and refers to a later chapter as regards qualification. In some parts of the world – Canada is a good example – ships were obliged to have an accredited ice navigator on board when operating in ice even before the guidelines were adopted and published. In recent years, the number of courses developed to teach ice recognition (there are more than thirty different types of recognised ice formations) and ice navigation has multiplied and there are even simulator courses available in some locations.

Chapter 12 of the guidelines is as follows…

12.1 Application.

It should be noted that the provisions prescribed in this chapter are not to be considered in addition to the requirements of SOLAS chapter V. Rather, any equipment fitted or carried in compliance with the requirements of SOLAS chapter V may be considered as part of the recommended equipment complement detailed in this chapter. Unless specifically provided in this chapter, the performance standards and other applicable guidance for equipment and systems contained in this chapter should be applied in accordance with SOLAS chapter V, as amended.

12.2 Compasses.

12.2.1 Magnetic variations in high latitudes may lead to unreliable readings from magnetic compasses.

12.2.2 Gyro-compasses may become unstable in high latitudes and may need to be shut down.

12.2.3 Companies should ensure that their systems for providing reference headings are suitable for their intended areas and modes of operation, and that due consideration has been given to the potential effects noted in paragraphs 12.2.1 and 12.2.2. For operations in polar waters, ships should be fitted with at least one gyro-compass and should consider the need for installation of a satellite compass or alternative means.

12.3 Speed and distance measurement.

12.3.1 All ships should be fitted with at least two speed and distance measuring devices. Each device should operate on a different principle in order to provide both speed through the water and speed over ground.

12.3.2 Speed and distance measuring devices should provide each conning position with a speed indication at least once per second.

12.3.3 Speed and distance measurement device sensors should not project beyond the hull and should be installed to protect them from damage by ice.

12.4 Depth sounding device. All ships should be fitted with at least two independent echo-sounding devices which provide indication of the depth of water under the keel. Due account should be taken of the potential for ice interference or damage to any device designed to operate below the waterline.

12.5 Radar installations.

12.5.1 All ships should be fitted with a total of at least two functionally independent radar systems. One of these should operate in the 3 GHz (10 cm, S-band) frequency range.

12.5.2 Radar plotting systems that may be installed should have the capability of operating in both the sea and the ground stabilized mode.

12.6 Electronic positioning and electronic chart systems.

12.6.1 All ships should be provided with an electronic position fixing system.

12.6.2 A satellite system (GPS or GLONASS or equivalent) should be fitted on any ship intending to navigate in areas outside of reliable coverage by a terrestrial hyperbolic system.

12.6.3 Systems described in paragraphs 12.6.1 and 12.6.2 should provide input to allow for continuous representation of the ship's speed provided by a speed and distance measuring device according to paragraph 12.3, and the ship's course provided by a compass according to paragraph 12.2.

12.6.4 Where fitted, electronic charting systems should be able to use position input from systems compliant with paragraphs 12.6.1 and 12.6.2.

12.7 Automatic identification system (AIS). All ships should be provided with automatic identification system (AIS).

12.8 Rudder angle indicator.

12.8.1 Separate rudder angle indicators should be provided for each rudder on ships with more than one independently operable rudder.

12.8.2 In ships without a rudder, indication should be given of the direction of steering thrust.

12.9 Searchlights and visual signals.

12.9.1 All ships operating in polar waters should be equipped with at least two suitable searchlights which should be controllable from conning positions.

12.9.2 The searchlights described in paragraph 12.9.1 should be installed to provide, as far as is practicable, all-round illumination suitable for docking, astern manoeuvres or emergency towing.

12.9.3 The searchlights described in paragraph 12.9.1 should be fitted with an adequate means of de-icing to ensure proper directional movement.

12.9.4 All ships that may be involved in an escort of more than one ship following in an ice track should be equipped with a manually initiated flashing red light visible from astern to indicate when the ship is stopped. This should be capable of use from any conning position. The flashing light should have a range of visibility of at least two (2) nautical miles. The colour and frequency of the flashing light should be according to standards given in COLREG. The horizontal and vertical arcs of visibility of the flashing light should be as specified for stern lights in COLREG.

12.10 Vision enhancement equipment.

12.10.1 All ships should be fitted with a suitable means to de-ice sufficient conning position windows to provide unimpaired forward and astern vision from conning positions.

12.10.2 The windows described in paragraph 12.10.1 should be fitted with an efficient means of clearing melted ice, freezing rain, snow, mist and spray from outside and accumulated condensation from inside. A mechanical means to clear moisture from the outside face of a window should have operating mechanisms protected from freezing or the accumulation of ice that would impair effective operation.

12.10.3 All persons engaged in navigating the ship should be provided with adequate protection from direct and reflected glare from the sun.

12.10.4 All indicators providing information to the conning positions should be fitted with means of illumination control to ensure readability under all operating conditions.

12.11 Ice routeing equipment.

12.11.1 All ships should be provided with equipment capable of receiving ice and weather information charts.

12.11.2 All ships operating in polar waters should be fitted with equipment capable of receiving and displaying ice imagery.

The additional requirements of Chapter 12 of the guidelines are not particularly onerous but the final requirement is one that equipment makers have responded to in a number of ways. Conventional marine radars are inadequate for ice navigation (except when following an icebreaker) because they make use of echo stretching, or expansion. This technique stretches' a radar echo to enable the target to be determined easily against background clutter. It is useful in high seas where the only high-intensity radar echoes are those from vessels, land or weather clutter but when used in ice the resultant radar image is at such a consistent high intensity that the radar operator must make adjustments to reduce the number of echoes – invariably removing many of the ice echoes.

With the prospect of extended navigation in arctic waters, several leading radar makers have developed systems specifically designed for use in ice-infested waters. These include Canadian maker Rutter, Simrad, Sweden's Consilium and Kelvin Hughes.

The technologies used by the companies to enhance their radar systems vary. Some prefer to make use of standard 9GHz X-band navigation radar with special software being used to enhance the image. Mention has already been made of Kelvin Hughes ETD radar systems and an ice version called MDICE is available as an upgrade. MDICE uses a scan-to-scan correlation technique which integrates the returns from a large number of scans to improve target detection. Advanced image processing techniques enhance the visual quality of these returns, allowing clearer target differentiation via a quasi-3D representation. Adjustments are possible to fine-tune the system to suit prevailing conditions.

The Simrad ARGUS system also uses enhanced software that can display different types of ice in different colours. This allows navigators to distinguish softer younger ice from more dangerous and older hard ice and solid objects. In order to gain the best image of the ice, Simrad advocates having a dedicated X-band ice radar with its antenna sited a little lower than the main S-band radar and says it is better still to have two ice radars located at a distance from each other. Coupled with the software this can produce an almost stereoscopic image and having two ice radars also adds a degree of redundancy. The software needed can be pre-loaded into the radars but will only be activated if an upgrade key is purchased.

An alternative method adopted by other system makers is to split the signal feed from the X-band antennae into two, with one branch going to the conventional display and the other to the ice radar display by way of a processor module containing the necessary software. Rutter's S6 radar is one such system but its display is 12 bit as opposed to the normal 4 bit maximum systems used by most vessels. This allows for a display with 256 intensity levels and a much higher definition. Rutter also plans to incorporate wave and current information into its products to generate more information for end users.

Because thermal imaging cameras rely on thermal contrast instead of colour contrast they do not need lighting to produce crisp images during the night.

Furuno's FICE-100 ice radar is another hybrid device and when installed is connected to Furuno FAR 2xx7ARPA navigation radar without affecting any of that device's properties or performance. Furuno says in its product description that the ice radar's principle of operation is the opposite of the navigation radar, so it is not suitable to the actual navigation. It requires its own processor and device in order to be efficient due its different calculation algorithms. Complementing radar with other methods of ice detection is a comparatively new idea. One means that has been tested by Kelvin Hughes is the use of thermal imaging cameras. The company the Kelvin Hughes worked with – FLIR – has also conducted its own tests in Greenland.

FLIR claims its equipment is of particular use for detecting smaller pieces of ice known as bergy bits and growlers.

A good lookout can spot these during daytime but at night the combination of darkness and fog or snow can limit the capability of regular eyesight to detect ice hazards even further.

Thermal imaging cameras record the intensity of electromagnetic radiation in the infrared spectrum. All matter emits infrared radiation and even cold objects such as ice emit infrared radiation. In a thermal imaging camera the infrared radiation is focused by a lens onto the detector. The intensity of the recorded infrared radiation is translated into a visual image. Because thermal imaging cameras rely on thermal contrast instead of colour contrast they do not need lighting to produce crisp images during the night. They provide a good overview of the situation giving a much better idea of the surroundings than the narrow beam of a searchlight. During tests in Greenland thermal imaging cameras were successfully used to detect pieces of ice of different sizes and shapes. These are generally divided into three categories: icebergs, bergy bits and growlers.

Icebergs are floating chunks of ice with more than 5 meters of its height exposed above sea level. Bergy bits are pieces of icebergs showing 1 to 5 meters above sea level. Growlers are pieces of icebergs showing less than 1 meter above sea level. With the thermal imaging camera all of those three categories were detected.

Due to their size icebergs are usually relatively easy to detect by radar. In most occasions using radar should suffice in detecting them. The bergy bits are smaller than full-grown icebergs, making them harder to detect, both by radar and visually.

Even the large bergy bits can be difficult to detect using marine radar, due to their shape. The sides of bergy bits are often oriented in such a way that radar energy is deflected away from the antennae. Combined with sea clutter this bergy bit characteristic can make it really difficult to spot them on the radar. During the test many bergy bits were observed with the thermal imaging camera, they showed up very clearly in the thermal image.

Growlers, being the smallest category, are the most difficult form of ice to detect both visually and on radar. Though small, growlers can still pose a serious threat even for ice strengthened vessels. Growlers made out of ice less than one year old should not be able to cause much damage to such vessels, if they maintain a safe speed. Due to its pressurized environment ice from glaciers and multi-year sea ice can have a much higher density, so growlers made of multi-year ice can be a lot heavier than those made out of the less dense younger ice.

Chapter 7 *Signals and Sensors*

Communicating with other ships

MODERN TECHNOLOGY PROVIDES ALTERNATIVES to most established systems and procedures but there are good reasons to maintain the much older and simpler systems in many cases. Even if it is possible to send messages and communicate by satellites or radio it is considered essential to prepare for failures and blackouts and to have alternate means of signalling intentions to other ships and reading theirs. Many of these means are not located on the bridge itself but are controlled from there and it falls to the navigation team to interpret the signals given by others.

Conceivably the oldest and most important are navigation lights. The types of lights required and their use are specified in The International Regulation for Preventing Collisions at Sea (COLREGS 1972).

Lights must be displayed from sunset to sunrise and during time of low or poor visibility so that nearby ships can navigate safely after seeing the navigation lights.

Five separate lights are fitted at different positions on the ship according to the requirements of the rules and these allow easy identification of the displaying ship's size, direction of travel or to indicate the ship is at anchor. Navigators learn the use of lights at an early stage in their education. The lights are:

- *Foremast - Bright White with a horizontal arc range of 225 degrees.*
- *Mainmast - Bright White is also known as all-round light has a horizontal arc visibility of 360 degrees.*
- *Port side - Bright Red with a horizontal arc visibility of 112.5 degrees.*
- *Starboard side - Bright Green with a horizontal arc visibility of 112.5 degrees*
- *Stern of the ship- Bright White with a horizontal arc visibility of 135 degrees.*

In addition to the above two anchor lights are fitted forward and aft and are bright white in colour. The power for the navigational lights is supplied from a separate distribution board which has no other supplies attached to it. This is done so that they cannot be put off by inadvertent operation of a wrong switch.

The mast head lights must be visible from a distance of 6 nautical miles for vessels over 50m in length and from 3 nautical miles for smaller vessels.

Due to the critical nature and essential safety requirement of navigational lights, they are fitted in duplex manner at each position. Two separate lamps or a lamp holder with dual fitting can also be used. All lights are switched from the bridge and any fuses must also be able to be changed on the bridge. A control panel must have indicator lamps and an alarm in case of failure of any light.

Another visual aid that must be available and used from the bridge is the Daylight Signalling Lamp which is mandatory on all ships above 150gt and all passenger vessels. The lamp must have its own emergency power source and in most cases this will be a battery kept in a constant state of charge. It will be used to send Morse signals to other vessels when appropriate. The use of the signalling lamp is now one of only two instances where Morse code remains in shipping (the other being the ship's whistle) following its phase out for radio communications under GMDSS.

Another requirement of COLREGs is that during daylight hours ships that are at anchor, being towed or not under control should display an appropriate shape from the fo'c'sle. These are known as the Black Ball or Black Diamond, the former being for ships at anchor and the latter for towed or Not Under Command (NUC) vessels.

As far as visual aids and signals go, the final requirement for ships that harks back to an earlier era but which is still relevant and mandatory is the carriage and occasional use of signal flags. The 26 alphabet flags and the substitute and numerical pennants can be used to signal a range of information with each of the letter flags having a unique meaning assigned according to The International Code of Signals 2003. More complex messages can be sent using combinations of letters and numbers Navigators are expected to know the meaning of the signal flags but a copy of the code is also required on the bridge. In cases of needs it is also possible to signal using semaphore flags but the use of VHF radio has made most such forms of signalling somewhat outmoded.

Another visual aid that must be available and used from the bridge is the Daylight Signalling Lamp which is mandatory on all ships above 150gt and all passenger vessels.

SOLAS requires all ships to have a means of signalling by sound and for merchant vessels this is covered by the requirement to be equipped with a whistle often erroneously referred to as a foghorn. Sound signals are made using Morse and the meanings attributed by the Signals Code.

Ships generally have two whistles, one electric and the other powered by compressed air. Sound signals are only of use if they can be heard, and in the fully enclosed bridge of modern ships that would not always be possible, therefore it is a requirement of SOLAS that such vessels should be equipped with a Sound Reception System that enables the navigating officer inside the cabin to listen to the sound signals and horns from other ships.

Chapter 8 *Manoeuvring and Positioning*

Staying on course and staying on station

AS REMOTE AS IT IS FROM THE engine room and rudder, the bridge is the place from which the ship is controlled. This requires a comprehensive control system that connects to the engine and steering gear by a combination of hydraulic, mechanical, electronic and electrical means and a system of indicators that returns information to those controlling the ship.

The controls of the various systems are often supplied by the bridge manufacturer for an integrated system of they can come from a third party such as Kvant Controls. Operation of the controls will vary and in many ships, the familiar system of wheel, knobs and levers has been replaced by a joystick.

In 2010, Kvant introduced a haptonomic module which can be used with its controls to give a positive feedback to the operator. This gives back some of the 'feel' that was inherent in older methods of control and allows the navigator to better understand what is happening at the rudder or propulsor. Although this may seem to be an unnecessary gimmick since the navigator has the readout display in clear sight, it has been shown to prevent excessive use of the control and thus eliminate the hazards and undesirable effects of systems being overloaded. Kvant's innovation has since been followed by others. The layout of the controls is considered to be part of the ergonomics of the bridge and placement will take into account the position from which they are normally operated. On some ferries and offshore vessels, the controls may even be partially incorporated in to the captain's chair.

The physical controls are normally sufficient for general use but emergencies do arise and all vessels are required to have a means of emergency steering which is invariably located as close to the rudder as possible and thus very far from the bridge. Those operating the emergency steering need to receive orders and so as well as voice communication to the engine room, there must also be a means to communicate directly with the emergency steering room from the bridge. There must also be a tannoy system for allowing commands to be broadcast throughout the vessel.

Many of the information display systems required under SOLAS vary depending upon the ship's size. All vessels above 300gt and all passenger ships are required to have a Speed and Distance measuring device for measuring speed and distance through the water (SOLAS regulation V/19.2.3.4). In addition ships of 50,000gt and over require a similar device for measuring speed over the ground in the forward and athwartships direction (SOLAS regulation V/19.2.9.2). Both devices if fitted should be connected to the ship's VDR. The devices are usually referred to as Doppler Speed Logs for the very simple reason that they operate using Doppler radar and a transceiver fitted to the ship's hull. Until very recently, it was considered sufficient for the requirements for the larger ships to be covered by installing a single device capable of both measurements.

However, in July 2013 following MSC90, the IMO issued a clarification that on ships requiring both devices (i.e. ships of 50,000gt and over) the requirement should be fulfilled by two separate devices: one speed and distance measuring and indicating device capable of measuring speed through water; and one separate speed and distance measuring and indicating device capable of measuring speed over the ground in the forward and athwartships direction. These amendments are published in IMO resolution MSC.334(90) and the IMO circular MSC.1/Circ.1429 and apply to devices installed on ships constructed on or after July 1, 2014.

Above 500gt, ships are also obliged to be fitted with a rudder angle indicator which, as the name indicates, provides information displaying the angle of the rudder. The same ships must also have a display indicating the thrust and pitch of the propeller(s) if they are fitted with controllable pitch propellers. On all ships above 50,000gt there is an additional requirement for a Rate of turn indicator to give information on how fast the ship is turning at a steady rate. The display is normally shown as number of degrees turned.

As a means to prevent the helmsman suffering from fatigue, ships of 10,000gt and above are required to be fitted with an autopilot. Autopilots, or heading control systems as they are commonly referred to, are also common on smaller vessels where their installation is not mandatory simply because of the benefits they can confer. The autopilot should not be used in high traffic areas and it is essential to keep a lookout whenever it is in use for obvious reasons.

The performance standards for autopilot systems are quite extensive and have adapted over time to cover evolving technology such as ECDIS. As a consequence autopilot systems now are capable of more than just maintaining the vessel on a pre-set heading with minimum operation of the ship's steering gear. Being connected to the gyro compass and GPS as well as the ECDIS, an autopilot can now be part of a track control system making turns and following a pre-determined passage plan. If the system is to make turns it should be connected to a suitable source of speed information and be able to perform turns, within the turning capability of the ship, based either on a pre-set turning radius or a pre-set rate of turn. Since some systems will be fitted with remote stations to which control can be delegated, it is also a requirement that the master station should have a means to regain control at any time. Finally the system must also incorporate alarms that operate if the vessel deviates from the pre-set course or if there is a failure or a reduction in the power supply to the heading control system or heading monitor, which would affect the safe operation of the equipment.

Dynamic Positioning

For most vessels complicated manoeuvres are only made when berthing or unberthing but for vessels working in certain sectors – particularly the offshore sector – the ability to accurately hold station for long periods is essential. Such vessels make use of Dynamic Positioning (DP).

A vessel fitted with DP has a computerised control system that automatically maintains a vessel's position and heading by using the ships propellers and thrusters to offset wind and current forces. Position reference sensors, combined with wind sensors, motion sensors and gyro compasses, provide information to the computer pertaining to the vessel's position and the magnitude and direction of environmental forces affecting its position.

The computer program needs to be populated with a mathematical model of the vessel that includes information pertaining to the wind and current drag of the vessel and the location of the thrusters. This knowledge, combined with the sensor information, allows the computer to calculate the required steering angle and thrust output for each thruster. Dynamic positioning may either be absolute in that the position is locked to a fixed point over the bottom, or relative to a moving object like another ship or an underwater vehicle.

As dynamic positioning systems are so specialised the manufacturing sector is quite small with Kongsberg Maritime, Rolls-Royce Marine, Navis Engineering and GE Power Conversion, DCNS and EMI being some of the best known names. There are presently three different classes of dynamic positioning systems recognised with increasing degrees of sophistication made possible by technological developments that have evolved since the first DP system was devised.

- *Equipment Class 1 has no redundancy. Loss of position may occur in the event of a single fault.*
- *Equipment Class 2 has redundancy so that no single fault in an active system will cause the system to fail. Loss of position should not occur from a single fault of an active component or system such as generators, thruster, switchboards, remote-controlled valves etc. but may occur after failure of a static component such as cables, pipes, manual valves etc.*
- *Equipment Class 3 which also has to withstand fire or flood in any one compartment without the system failing. Loss of position should not occur from any single failure including a completely burnt fire sub division or flooded watertight compartment.*

Manoeuvring and Positioning

For ships to remain in one position requires highly accurate position referencing. This can be supplied either by satellite positioning or from a fixed point on the seabed if the vessel involved is a drilling unit or similar. If satellite position fixing is used it should be noted that the position obtained by GPS is not accurate enough for use by DP and Differential GPS (DGPS) is required. DGPS makes use of a fixed ground-based reference station (differential station) that compares the GPS position to the known position of the station. The correction is sent to the DGPS receiver by long wave radio frequency. For use in DP an even higher accuracy and reliability is needed.

Companies such as Veripos, Fugro or C&C Technologies supply differential signals via satellite, enabling the combination of several differential stations. There are also systems installed on vessels that use various Augmentation systems, as well as combining GPS position with GLONASS.

The choice of DP class for particular tasks is a matter for the shipowner and the client although in territorial waters the state involved may impose rules. In Norwegian waters for example, the Norwegian Maritime Authority(NMA) has specified what Class should be used in regard to the risk of an operation. In the NMA Guidelines four classes are defined:

- ***Class 0 Operations where loss of position keeping capability is not considered to endanger human lives, or cause damage.***
- ***Class 1 Operations where loss of position keeping capability may cause damage or pollution of small consequence.***
- ***Class 2 Operations where loss of position keeping capability may cause personnel injury, pollution, or damage with large economic consequences.***
- ***Class 3 Operations where loss of position keeping capability may cause fatal accidents, or severe pollution or damage with major economic consequences.***

Although DP systems employ computers to make the rapid adjustments to thrusters needed to maintain position, the overall operation must be monitored and controlled by trained DP Operator (DPOs). The main role of the DPO is to determine whether there is enough redundancy available at any given moment of the operation and to take appropriate action in the case of any equipment failure. In 1996 the IMO issued MSC/Circ.738 (Guidelines for dynamic positioning system (DP) operator training).

Although the IMO has issued the guidelines for DO Operator training it is a fact that in many of the main offshore oil and gas fields, rules other than SOLAS and MARPOL take precedence within a set distance from offshore facilities. These rules are drawn up by national health and safety authorities and there are differences depending on where ships are operating. In addition the charterers of offshore ships often have their own requirements for DP operator experience and qualifications.

The question of DP operator training is somewhat complicated with competing qualification bodies active and some operators, charterers and authorities not recognising all of them. The situation warrants a chapter of its own in the ShipInsight Training & Simulation Guide.

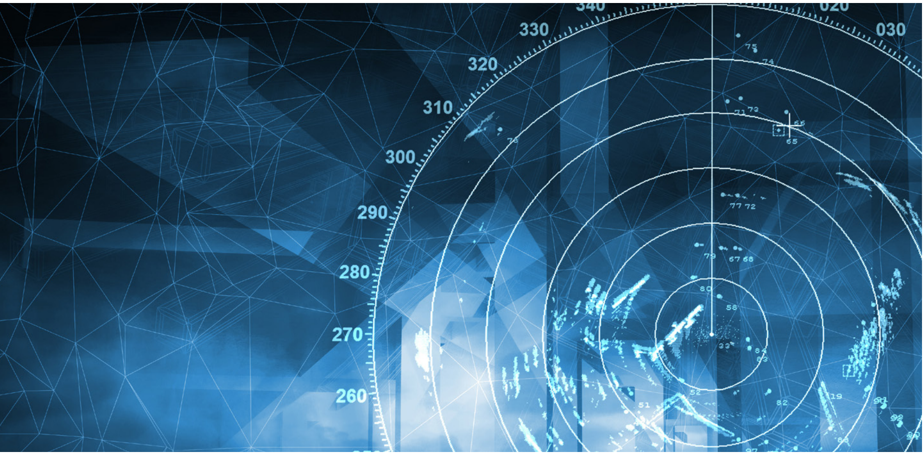
Currently there is no requirement under STCW for any mandatory training or minimum competency standards. The only mention of dynamic positioning operations in STCW 2010 is in part B which is recommended only. The relevant section is B-V/f.

The proliferation of different schemes and the fact that the US Coast Guard is paying close attention to DP related issues following various incidents including a sheared wellhead caused during DP operations is likely to lead to moves for some standardisation. While many would prefer to work within the scope and framework of the current industry systems there are others who would prefer to see DP brought into the mandatory section of STCW and even the possible development of an IMO model course.

DP training is offered by a number of training centres and almost always involves a large measure of simulator training. With ever more DP ships and with increasing manpower demands, the position of DPO is gaining increasing prominence. This has resulted in the creation of The International Dynamic Positioning Operators Association (IDPOA) as a trade body for qualified and aspiring DPOs. The organisation has a useful website at http://www.dpoperators.org/

Chapter 9 *Recording and Planning*

Logs and passage planning for safer voyaging



IN SPITE OF ALL THE TECHNOLOGY that is to be found on the bridge of a modern day ship, there are still some types of information that are considered essential to be in writing. Certain books are considered necessary even if their presence is not mandatory. Copies of SOLAS and MARPOL might be on board but kept in the master or mate's cabin but more practical publications such as COLREGs and the Signals Code should always be within easy reach. Some books such as the ITU list of call signs are a requirement under GMDSS but might be consulted by the bridge team for routine operational reasons.

Information about the ship's manoeuvring characteristics is important to the navigating team and to any pilots that may board the ship at any time. In accordance with IMO Resolution A.601(15) Provision and Display of Manoeuvring Information on Board Ships and A.751(18) adopted on November 4, 1993 Interim Standards for Ship Manoeuvrability, Manoeuvring information should be presented as follows:

Pilot Card

The Pilot Card to be filled in by master is intended to provide information to the pilot on boarding the ship. This information should describe the present condition of the ship, with regard to its loading, propulsion and manoeuvring equipment, and other relevant equipment. The contents of the Pilot Card are available for use without conducting special manoeuvring trials.

Wheelhouse Poster

The Wheelhouse Poster should be permanently displayed in the wheelhouse and should contain general particulars and detailed information describing the manoeuvring characteristics of the ship, and be of such the size to ensure ease of use. The manoeuvring performance of the ship may differ from that shown on the Poster due to environmental, hull and loading conditions.

Manoeuvring Booklet

The Manoeuvring Booklet should be available on board and should contain comprehensive details of the other relevant data. The Manoeuvring Booklet should include the information shown on the available manoeuvring information. Most of the manoeuvring information in Booklet can be estimated but some should be obtained from trials. The information in the Booklet may be supplemented in the course of the ship's life.

The manoeuvring information should be amended after modification or conversion of the ship, which may after its manoeuvring characteristics or extreme dimensions.

Going to plan

Since the purpose of navigation is to get safely from one place to another, perhaps the most essential item is the passage plan which can exist both in written form and also as an electronic version programmed in to an ECDIS or track control system. Proper passage planning should take in to account not only the shortest or most economic route but also hazards that may be encountered on the voyage. Passage planning is a lesson taught to navigators at most nautical colleges and the IMO has produced its own guidelines on the subject.

Recording and Planning

GUIDELINES FOR VOYAGE PLANNING
(IMO Resolution A.893(21)

1. Objectives

- *1.1 The development of a plan for voyage or passage, as well as the close and continuous monitoring of the vessel's progress and position during the execution of such a plan, are of essential importance for safety of life at sea, safety and efficiency of navigation and protection of the marine environment.*
- *1.2 The need for voyage and passage planning applies to all vessels. There are several factors that may impede the safe navigation of all vessels and additional factors that may impede the navigation of large vessels or vessels carrying hazardous cargoes. These factors will need to be taken into account in the preparation of the plan and in the subsequent monitoring of the execution of the plan.*
- *1.3 Voyage and passage planning includes appraisal, i.e. gathering all information relevant to the contemplated voyage or passage; detailed planning of the whole voyage or passage from berth to berth, including those areas necessitating the presence of a pilot; execution of the plan; and the monitoring of the progress of the vessel in the implementation of the plan. These components of voyage/passage planning are analysed below.*

2. Appraisal

- *2.1 All information relevant to the contemplated voyage or passage should be considered. The following items should be taken into account in voyage and passage planning:*
- *2.1.1 the condition and state of the vessel, its stability, and its equipment; any operational limitations; its permissible draught at sea in fairways and in ports; its manoeuvring data, including any restrictions;*
- *2.1.2 any special characteristics of the cargo (especially if hazardous), and its distribution, stowage and securing on board the vessel;*
- *2.1.3 the provision of a competent and well-rested crew to undertake the voyage or passage;*
- *2.1.4 requirements for up-to-date certificates and documents concerning the vessel, its equipment, crew, passengers or cargo;*
- *2.1.5 appropriate scale, accurate and up-to-date charts to be used for the*

intended voyage or passage, as well as any relevant permanent or temporary notices to mariners and existing radio navigational warnings;

- *2.1.6 accurate and up-to-date sailing directions, lists of lights and lists of radio aids to navigation; and*
- *2.1.7 any relevant up-to-date additional information, including:*
- *2.1. 7.1 mariners' routeing guides and passage planning charts, published by competent authorities; 2.1. 7.2 current and tidal atlases and tide tables;*
- *2.1. 7.3 climatological, hydrographical, and oceanographic data as well as other appropriate meteorological information;*
- *2.1. 7.4 availability of services for weather routeing (such as that contained in Volume D of the World Meteorological Organization's Publication No. 9);*
- *2.1. 7.5 existing ships' routeing and reporting systems, vessel traffic services, and marine environmental protection measures;*
- *2.1. 7.6 volume of traffic likely to be encountered throughout the voyage or passage;*
- *2.1. 7.7 if a pilot is to be used, information relating to pilotage and embarkation and disembarkation including the exchange of information between master and pilot;*
- *2.1. 7.8 available port information, including information pertaining to the availability of shore-based emergency response arrangements and equipment; and*
- *2.1. 7.9 any additional items pertinent to the type of the vessel or its cargo, the particular areas the vessel will traverse, and the type of voyage or passage to be undertaken.*
- *2.2 On the basis of the above information, an overall appraisal of the intended voyage or passage should be made. This appraisal should provide a clear indication of all areas of danger; those areas where it will be possible to navigate safely, including any existing routeing or reporting systems and vessel traffic services; and any areas where marine environmental protection considerations apply.*

3. Planning

- *3.1 On the basis of the fullest possible appraisal, a detailed voyage or passage plan should be prepared which should cover the entire voyage or passage from berth to berth, including those areas where the services of a pilot will be used.*
- *3.2 The detailed voyage or passage plan should include the following factors:*

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- ***3.2.1 the plotting of the intended route or track of the voyage or passage on appropriate scale charts: the true direction of the planned route or track should be indicated, as well as all areas of danger, existing ships' routeing and reporting systems, vessel traffic services, and any areas where marine environmental protection considerations apply;***
- ***3.2.2 the main elements to ensure safety of life at sea, safety and efficiency of navigation, and protection of the marine environment during the intended voyage or passage; such elements should include, but not be limited to:***
- ***3.2.2.1 safe speed, having regard to the proximity of navigational hazards along the intended route or track, the manoeuvring characteristics of the vessel and its draught in relation to the available water depth;***
- ***3.2.2 2 necessary speed alterations en route, e.g., where there may be limitations because of night passage, tidal restrictions, or allowance for the increase of draught due to squat and heel effect when turning;***
- ***3.2.2.3 minimum clearance required under the keel in critical areas with restricted water depth;***
- ***3.2.2.4 positions where a change in machinery status is required; 3.2.2.5 course alteration points, taking into account the vessel's turning circle at the planned speed and any expected effect of tidal streams and currents;***
- ***3.2.2.6 the method and frequency of position fixing, including primary and secondary options, and the indication of areas where accuracy of position fixing is critical and where maximum reliability must be obtained;***
- ***3.2.2.7 use of ships' routeing and reporting systems and vessel traffic services;***
- ***3.2.2.8 considerations relating to the protection of the marine environment;***
- ***3.2.2.9 contingency plans for alternative action to place the vessel in deep water or proceed to a port of refuge or safe anchorage in the event of any emergency necessitating abandonment of the plan, taking into account existing shore-based emergency response arrangements and equipment and the nature of the cargo and of the emergency itself.***
- ***3.3 The details of the voyage or passage plan should be clearly marked and recorded, as appropriate, on charts and in a voyage plan notebook or computer disk.***
- ***3.4 Each voyage or passage plan as well as the details of the plan, should be approved by the ships' master prior to the commencement of the voyage or passage.***

Recording and Planning

4. Execution

- *4.1 Having finalized the voyage or passage plan, as soon as time of departure and estimated time of arrival can be determined with reasonable accuracy, the voyage or passage should be executed in accordance with the plan or any changes made thereto.*
- *4.2 Factors which should be taken into account when executing the plan, or deciding on any departure therefrom include:*
- *4.2.1 the reliability and condition of the vessel's navigational equipment;*
- *4.2.2 estimated times of arrival at critical points for tide heights and flow;*
- *4.2.3 meteorological conditions, (particularly in areas known to be affected by frequent periods of low visibility) as well as weather routeing information;*
- *4.2.4 daytime versus night-time passing of danger points, and any effect this may have on position fixing accuracy; and*
- *4.2.5 traffic conditions, especially at navigational focal points.*
- *4.3 It is important for the master to consider whether any circumstance, such as the forecast of restricted visibility in an area where position fixing by visual means at a critical point is an essential feature of the voyage or passage plan, introduces an unacceptable hazard to the safe conduct of the passage; and thus whether that section of the passage should be attempted under the conditions prevailing or likely to prevail. The master should also consider at which specific points of the voyage or passage there may be a need to utilize additional deck or engine room personnel.*

5. Monitoring

- *5.1 The plan should be available at all times on the bridge to allow officers of the navigational watch immediate access and reference to the details of the plan.*
- *5.2 The progress of the vessel in accordance with the voyage and passage plan should be closely and continuously monitored. Any changes made to the plan should be made consistent with these Guidelines and clearly marked and recorded.*

The advent of ECDIS has brought about a major change in the way passage planning is undertaken on some ships with some systems having passage planning features that can produce plans more or less automatically taking into account various parameters entered into the system by the navigating officer. These features are intended as improving safety but they have been identified as being implicated in a number of grounding incidents over the last few years.

In most cases the problem has not been a failing of the feature itself but more a matter of unfamiliarity and misunderstanding of messages and alerts generated by the passage planning feature. ECDIS also permits passage plans to be stored and used again for future voyages. While this can be a labour saving feature there should always be a validation of the passage plan for each voyage. In particular attention should be paid to checking that the ENC data has been updated for new hazards and also that the stored plan is appropriate for changed parameters such as increased draught.

ECDIS is still not a feature that is found on every ship and it is almost certain that as experience is gained during the mandatory -rollout period new problems will emerge connected with operation in general and passage planning in particular. During the introduction period, prudent ship operators should endeavour to keep informed of any issues that arise and ensure that details are disseminated to crews at sea.

Logs in the modern era

Reference has already been made to the ship's log which is officially referred to as the Record of Navigation Activities. Some administrations have begun to permit vessels to maintain an electronic log book and of course more comprehensive information than was ever recorded in a paper log book can be found on a properly installed and functioning VDR. An advantage of an electronic log (which can be for all logs including engine, radio etc) is that the information can be transmitted ashore on a regular basis so that in the event of loss of the vessel, the log records could still be accessible. If an electronic form of log is permitted, there must be some means for information to be accessed by authorities and possibly by insurers and others with an interest in the vessel such as time charterers. In addition to the navigation log, there is also a requirement to keep a Record of Maintenance of Navigational Equipment. A hard copy of the record must be present onboard ships for ready reference of port and regulatory authorities and must be signed by master and duty officers of the ship. As the name suggests, it should record all service activity.

Shipping is a fascinating and many-faceted industry keeping the wheels of global commerce turning in the most efficient manner. It is also a highly regulated industry and the level of regulation and administrative burden is growing year by year. Keeping up to speed with all the latest developments in both regulation and technology is not an easy task and those entrusted to doing so need all the help they can get.

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