SEAFARERS TRAINING CENTER INC

RADAR, ARPA, BRIDGE TEAMWORK AND SEARCH AND RESCUE

In accordance to International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended.

AIMS

The aim of this model is to meet the mandatory minimum standards of competence for seafarers in Navigation for the Function: Maintain safe navigation through the use of information from navigation equipment and systems to assist command decision-making at th management level as specified in table A-II/2 of the STCW code

OBJECTIVE

The objective is to provide trainees with guidance and information to gain knowledge, understanding and proficiency (KUP) required to achieve the objectives of the learning outcomes to demonstrate the standard of competence in Navigation at the Management Level assigned to shipboard duties as required in section A-II/2 and out in table A-II/2 of Th STCW Code

ENTRY STANDARDS

This course is principally intended for trainees at the management level for radar navigation on board Prior to entering the course , trainees should be officers in charge of a navigational watch . Satisfy the minimum requirements set out in STCW Code , table A-II/1 (Certificate Radar Navigation at Operational level , IMO Course 1.07)

COURSE INTAKES LIMITATIONS

Course intakes should be limited by number of trainees who can receive adequate individual attention from the instructor.

STAFF REQUIREMENTS

The instructor shall have appropriate training in instructional techniques and training methods, and should be appropriately qualified in accordance with the provisions of STCW Code, section A-I/6.

TEACHING FACILITIES AND EQUIPMENT

Simulators used for the training should provide a controllable environment and sufficient own -ship stations to accommodate the trainees for each course.

TEACHING AIDS

Power Point
Simulator

BIBLIOGRAPHY

https://www.britannica.com/technology/radar/Factors-affecting-radar-performance

https://www.explainthatstuff.com/radar.html

https://www.marineinsight.com/marine-navigation/marine-radars-and-their-use-in-the-shipping-industry/

Knowledge, understanding and proficiency	Lecture (hours)	Practical training (hours)
1. Proficiency in the radar system and related resources	1.0	2.0
1.1 Requirements of STCW, SOLAS, COLREG and Performance Standards for Radar	0.3	
Equipment and related applications	0.4	
1.2 Operation principles of radar system, factors affecting radar information accuracy, radar characteristics and limitations	0.3	2.0
1.3 Awareness of radar working conditions		
Practical Training1 Awareness of radar working conditions		
2. Use of radar in navigation	3.0	9.0
2.1 Making a voyage plan	2.0	
2.2 Executing a voyage plan	1.0	
Practical Training 2 Use of radar in navigation		9.0
3. Use of radar in collision avoidance	3.0	9
3.1 Use of radar acquiring information for collision avoidance	1.0	
3.2 Use of radar in collision avoidance actions	2.0	
Practical Training3 Use of radar in collision avoidance		9
4. Use of radar in search and rescue (SAR)	3.0	6
4.1 Identification and confirmation of distress locating signals	1.0	
4.2 Use of radar in SAR operations	2.0	
Practical Training 4 Use of radar in search and rescue		6
Total 36.0	10.0	26

1. PROFICIENCY IN THE RADAR SYSTEM AND RELATED SOURCES.

1.1 Requirements of STCW, SOLAS, COLREG and Performance Standards for Radar Equipment and related applications

.1 describe the standard of competence on radar navigation in the KUPs of the STCW Code for personnel at the management level.

The STCW Convention provides seafarers with minimum training requirements for certification of competence. For the function of navigation at the management level, the KUPs in part A of the STCW Code related to radar navigation are covered in the competence requirements as follows:

.1 plan a voyage and conduct navigation;
.2 determine position and the accuracy of resultant position fixing by any means;
.3 coordinate search and rescue operations;
.4 establish watchkeeping arrangements and procedures; and
.5 maintain safe navigation through the use of information from navigation equipment and systems to assist command decision-making.

The mandatory minimum standards of competence for seafarers in Navigation for the Function: Maintain safe navigation through the use of information from navigation equipment and systems to assist command decision-making at the Management Level as specified in table A-II/2 of the STCW Code and includes the training related to acquiring, analyzing and applying radar resources to manage proper command decision-making with regard to safe navigation and successful search and rescue, to meet the mandatory requirements relating to the radar system: "plan a voyage and conduct navigation", "determine position and the accuracy of resultant position fix by any means", "coordinate search and rescue operations", "establish watchkeeping arrangements and procedures" as set out in section A-II/2 of the STCW Code.

.2 Express the resolution on the performance standards for radar systems in the SOLAS convention , as well as the number of radar sets and bands required for ships of different tonnage .

The SOLAS Convention sets out the minimum standards for ship construction, carriage requirements for equipment and safe operation of ships. Trainees should gain an understanding of SOLAS Convention, Chapter V, Regulation 18 which relates to type approval, surveys and performances of radar equipment.

Regulation 18 - Approval, surveys and performance standards of navigational systems and equipment and voyage data recorder
Summary

Equipment required by Regulations 19 and 20 fitted on or after 1 July 2002 must conform with the relevant IMO Performance Standards

Administration to ensure that equipment meet the relevant standards and that quality procedures ensure final product verification.

Equipment fitted on ships built before 1 July 2002, when replaced, must comply as closely as possible with the IMO Standards.

Equipment additional to the carriage requirements must be approved and comply as closely as possible with the IMO Standards. The AIS and the VDRs and their sensors each require an annual performance test.

Regulation 18
1.Systems and equipment required to meet the requirements of regulations 19 and 20 shall be of a type approved by the Administration.

2.Systems and equipment, including associated back-up arrangements, where applicable, installed on or after 1 July 2002 to perform the functional requirements of regulations 19 and 20 shall conform to appropriate performance standards not inferior to those adopted by the Organization.*

3. When systems and equipment are replaced or added to on ships constructed before 1 July 2002, such systems and equipment shall, in so far as is reasonable and practicable, comply with the requirements of paragraph 2.

4. Systems and equipment installed prior to the adoption of performance standards by the Organization may subsequently be exempted from full compliance with such standards at the discretion of the Administration, having due regard to the recommended criteria adopted by the Organization. However, for an electronic chart display and information system (ECDIS) to be accepted as satisfying the chart carriage requirement of regulation 19.2.1.4, that system shall conform to the relevant performance standards not inferior to those adopted by the Organization in effect on the date of installation, or, for systems installed before 1 January 1999, not inferior to the performance standards adopted by the Organization on 23 November 1995 **.

5. The Administration shall require that the manufacturers have a quality control system audited by a competent authority to ensure continuous compliance with the

type approval conditions. Alternatively, the Administration may use final product verification procedures where the compliance with the type approval certificate is verified by a competent authority before the product is installed on board ships.

6. Before giving approval to systems or equipment embodying new features not covered by this chapter, the Administration shall ensure that such features support functions at least as effective as those required by this chapter.

7. When equipment, for which performance standards have been developed by the Organization, is carried on ships in addition to those items of equipment required by regulations 19 and 20, such equipment shall be subject to approval and shall as far as practicable comply with performance standards not inferior to those adopted by the Organization.

8. The voyage data recorder system, including all sensors, shall be subjected to an annual performance test. The test shall be conducted by an approved testing or servicing facility to verify the accuracy, duration and recoverability of the recorded data. In addition, tests and inspections shall be conducted to determine the serviceability of all protective enclosures and devices fitted to aid location. A copy of the certificate of compliance issued by the testing facility, stating the date of compliance and the applicable performance standards, shall be retained on board the ship.

9. The automatic identification system (AIS) shall be subjected to an annual test. The test shall be conducted by an approved surveyor or an approved testing or servicing facility. The test shall verify the correct programming of the ship static information, correct data exchange with connected sensors as well as verifying the radio performance by radio frequency measurement and on-air test using, e.g., a Vessel Traffic Service (VTS). A copy of the test report shall be retained on board the ship.

The minimum performance standards of radar and/or ARPA, installed on or after 1 July 2002, shall meet requirements not inferior to those adopted by IMO. Those performance standards include:

- Recommendation on performance standards for radar equipment (Annex 4 of Resolution MSC. 64(67));
- Revised recommendation on performance standards for radar equipment (Annex of Resolution MSC. 192 (79)); and
- Performance standards for automatic radar plotting aids (Annex of Resolution A. 823(19)).

When radar and/or ARPA are replaced or added on to ships constructed before 1 July 2002, such systems and equipment shall, in so far as is reasonable and practicable, comply with the above-mentioned performance standards. Radar and ARPA installed prior to the adoption of performance standards by the Organization may subsequently be exempted from full compliance with such standards at the discretion of the Administration, having due regard to the recommended criteria adopted by the Organization.

With regard to the type and number of radars, as stipulated in Regulation 19 of SOLAS Convention, Chapter V, trainees should have an understanding that all ships of 300 gross tonnage and upwards, and passenger ships irrespective of size, shall be fitted with a 9 GHz radar.
In addition to the above equipment, all ships of 500 gross tonnage and upwards shall have an automatic tracking aid. In addition to the above equipment, all ships of 3,000 gross tonnage and above shall have a 3 GHz radar or, where considered appropriate by the Administration, a second 9 GHz radar and a second automatic tracking aid.

Regulation 19 - Carriage requirements for shipborne navigational systems and equipment

Summary
Navigational equipment - carriage requirements for new ships.
Requirements are based on tonnage and are cumulative.
Existing ships may continue to meet requirements of SOLAS Chapter V/74, except GNSS / terrestrial navigation receiver to be fitted at first survey after 1 July 2002, and AIS transponder to be fitted by specified dates.
Each item of equipment to comply with the relevant IMO Performance Standards.
Regulations allow for "other means" to be used to comply with the functional requirements of each equipment item.

All ships of 500 gross tonnage and upwards shall, in addition to meeting the requirements of paragraph 2.3 with the exception of paragraphs 2.3.3 and 2.3.5, and the requirements of paragraph 2.4, have:
2.5.5 an automatic tracking aid, or other means, to plot automatically the range and bearing of other targets to determine collision risk.

2.7 All ships of 3000 gross tonnage and upwards shall, in addition to meeting the requirements of paragraph 2.5, have:
2.7.1 a 3 GHz radar or where considered appropriate by the Administration a second 9 GHz radar, or other means to determine and display the range and bearing of other surface craft, obstructions, buoys, shorelines and navigational marks to assist in navigation and in collision avoidance, which are functionally independent of those referred to in paragraph 2.3.2; and
2.7.2 a second automatic tracking aid, or other means to plot automatically the range and bearing of other targets to determine collision risk which are functionally independent of those referred to in paragraph 2.5.5.

2.8 All ships of 10,000 gross tonnage and upwards shall, in addition to meeting the requirements of paragraph 2.7 with the exception of paragraph 2.7.2, have:
An automatic radar plotting aid, or other means, to plot automatically the range and bearing of at least 20 other targets, connected to a device to indicate speed and distance through the water, to determine collision risks and simulate a trial manoeuvre; and a heading or track control system, or other means, to automatically control and keep to a heading and/or straight track.

.3 Illustrate the influences of COLREG on collision avoidance decision-making with regard to the use of radar to maintain a proper lookout, to determine the reasonable safe speed , to appraise the risk of collision and to take effective action timely for collision avoidance; interpret the implications and influences of scanty radar information on safe navigations

As required by Rule 5, 6, 7, 8 and 19 of COLREG, radar should be used to maintain a proper look-out, to navigate at a safe speed, to determine the risk of collision, and to take efficient avoiding actions in time. The limitations of the radar equipment and scanty radar information may pose potential threats to navigation.

OOWD should be thoroughly knowledgeable and have a full understanding of radar related rules in the COLREG and emphasize: the integrity of radar collision avoidance information from the point of view of modern radar information processing; and the reliability of radar collision avoidance information from the point of view of information accuracy. Gain a thorough understanding of the application of Rules 5, 6, 7, 8 and 19 of the COLREG.

Rule 5 Look-out . Every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 6 Safe speed . Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. In determining a safe speed the following factors shall be among those taken into account:
(a). By all vessels:
(i). the state of visibility;
(ii). the traffic density including concentrations of fishing vessels or any other vessels;
(iii). the manoeuvrability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions;

(iv). at night the presence of background light such as from shore lights or from back scatter of her own lights;
(v). the state of wind, sea and current, and the proximity of navigational hazards;
(vi). the draught in relation to the available depth of water.

(b). Additionally, by vessels with operational radar:
(i). the characteristics, efficiency and limitations of the radar equipment;
(ii). any constraints imposed by the radar range scale in use;
(iii). the effect on radar detection of the sea state, weather and other sources of interference;
(iv). the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range;
(v). the number, location and movement of vessels detected by radar;
(vi). the more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity.

Rule 7 Risk of collision
(a). Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.
(b). Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.
(c). Assumptions shall not be made on the basis of scanty information, especially scanty radar information.
(d). In determining if risk of collision exists the following considerations shall be among those taken into account:
(i). such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change;
(ii). such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.

Rule 8 Action to avoid collision
(a). Any action to avoid collision shall be taken in accordance with the Rules of this Part and shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.
(b). Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided.

(c). If there is sufficient sea-room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.

(d). Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear.

(e). If necessary to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.

(i). A vessel which, by any of these Rules, is required not to impede the passage or safe passage of another vessel shall, when required by the circumstances of the case, take early action to allow sufficient sea-room for the safe passage of the other vessel.

(ii). A vessel required not to impede the passage or safe passage of another vessel is not relieved of this obligation if approaching the other vessel so as to involve risk of collision and shall, when taking action, have full regard to the action which may be required by the Rules of this part.

(iii). A vessel the passage of which is not to be impeded remains fully obliged to comply with the Rules of this part when the two vessels are approaching one another so as to involve risk of collision.

Rule 19 Conduct of vessels in restricted visibility

(a). This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

(b). Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate manoeuvre.

(c). Every vessel shall have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the Rules of section I of this part.

(d). A vessel which detects by radar alone the presence of another vessel shall determine if a close-quarters situation is developing and/or risk of collision exists. If so, she shall take avoiding action in ample time, provided that when such action consists of an alteration of course, so far as possible the following shall be avoided:

(i). an alteration of course to port for a vessel forward of the beam, other than for a vessel being overtaken;

(ii). an alteration of course towards a vessel abeam or abaft the beam.

(e). Except where it has been determined that a risk of collision does not exist, every vessel which hears apparently forward of her beam the fog signal of another vessel, or which cannot avoid a close-quarters situation with another vessel forward of her beam, shall reduce her speed to the minimum at which she can be kept on her course. She shall if necessary take all her way off and in any event navigate with extreme caution until danger of collision is over.

.4 **Generalize the requirements of different IMO resolutions on radar performance standards for radar equipment in the detection range , discrimination , detection accuracy , clutter suppression , target tracking etc. , analyze the impact of backup and fallback arrangements in case of partial malfunction of radar system**

According to the SOLAS Convention, radar and ARPA on board may follow different performance standards. OOWD should be made aware of the different standards that are applicable for compliance purposes. Make the varying requirements regarding the detection range, discrimination, accuracy, anti-clutter and target tracking.

Performance standards for radar and ARPA are combined into one instrument by Resolution MSC. 192 (79). ARPA is no longer the single equipment and is covered under the "target tracking" function in the radar system.

OOWD should be familiar with the backup and fallback arrangements to maintain minimum basic radar functionality in the event of partial failures, including information failure in terms of heading, speed through water, course and speed over ground, position, radar video, AIS input and network system.

OOWD should pay special attention to the fact that the radar equipment should switch automatically to the unsterilized head up mode within one minute after the azimuth stabilization has become ineffective, and that if automatic anti-clutter processing could prevent the detection of targets in the absence of appropriate stabilization, the processing should switch off automatically under the same circumstances.

1.2 Operation principles of radar system, factors affecting radar information accuracy, radar characteristics and limitations.

In this part, we review the relevant knowledge relating to radar working principles in Model Course 1.07, factors affecting the accuracy of radar information, characteristics and limitations of radar. In particular, During the classroom demonstration and practice emphasize that functions such as the integrity of sensor data, radar system setting and image adjustment, radar information processing mechanism impose a significant impact on proper acquisition of radar information and safe navigation.

During the training, we will emphasize the stress that overreliance on radar information may give rise to risks and endanger the safety of navigation. It is advisable to take the case study approach to help OOWD to better understand the performance of radar under various conditions of weather, sea states and visibility.

.1 Analyze the principles of radar detection, information processing and display, evaluate the influence of sensor errors, noises, clutters and false echoes on radar image presentation.

The effects of sensor error, noise, clutters and false echoes on the radar image presentation following a review of the knowledge related to radar receiving, processing and display principles of echoes in model course 1.07, including antenna receiving characteristics, analog/digital conversion, sensor information processing, target tracking and presentation process.

False echoes can be found:
Indirect Echoes: They are caused by the reflection of the beam radiated by the antenna in major ship structures, this beam reaches a real white and produces a blip from the wrong direction, having walked the same path back to the antenna. We can reduce them by raising the height of the antenna above the other structures of the ship.

As characteristics of them we can say that or usually appear in the radar shadow areas, or appear at the same distance as the real echo.

Multiple echoes: may occur in the presence of ships at close range, especially when it comes to large vessels. The radar signal undergoes multiple reflections between own ship and the target generating a second echo of the same target, located at twice the distance that the first echo. This phenomenon can be repeated to generate two, three or more echoes.

Echoes side: they are produced by the energy radiated by the antenna side lobes. The emitted beam is not perfect, has a secondary or main lobe and side lobes. Most of the energy is radiated as the main lobe. The greater the length of the antenna can concentrate better beam irradiated.

Gain (GAIN) adjusts the receiver sensitivity by varying the intensity of the echoes on the screen. Must be adjusted so that the display is a faint image of "noise" background. To adjust control should vary from zero to maximum and observe the changes that occur on the screen, then left it to the appropriate value. Too low a setting will cause the loss of weak echoes and reduced detection range. Over tightening may provoke low contrast, masking return echoes within the sea and the "noise" that appear on screen. The value is set according to the scale in use increasing it when the target is long-range detection. Decrease the gain temporarily can help differentiate strong echoes of weak (detect, for example, a lighthouse on a low coast for the purpose of positioning) Here are three pictures where we see three different conditions gain adjustment.

Excessive Gain
Tuning (TUNE): the methods we have to adjust the tuning of the receiver are:
Earth or vessels in sight: the gain value below normal is reduced, and operates on the tuning control to get the best possible image, preferably the weaker echoes, then back the gain value Normal.
Monitor Operating is a device used to evaluate the power of the transmitted signal and the receiver sensitivity (and therefore the correct tuning). We will describe a modern model, being able to find other models in different operating older equipment:

Totally independent of radar equipment without any interconnection network requires power the ship. Normally positioned aft of the antenna, only works on scale of 24 MN. Generates on screen several arcs in the direction in which it is placed. Under optimum operating conditions for transmitting and receiving the first of the arcs appear at 12 MN away, and are four of them in total. If the transmitter power is reduced, the first of the arcs appear closer to the center of the screen. If the receiver sensitivity is lower than normal amount of visible arches is reduced.

Sea or Return: We can serve as an indication; move the control to achieve maximum return on Tues. Then apply the corresponding filter (SEA CLUTTER).
Automatic: function possessing some radar receiver tuning adjust automatically.
Contrast (CONTRAST): This control works similar to a television, darkening the background and making bright echoes causing them to stand out.
Reducing interference other radars (INTERFERENCE REJECTION): (9 Ghz - X or 3 Ghz Band - Band S) in the case of vessels operating in the vicinity, having radar working in the same frequency band, mutual interference may occur. Are removed conveniently by activating a circuit which shifts the frequency band
Removal of sea clutter (A / C SEA - Anti-Clutter Sea), also called Sensitivity Time Control STC. The disturbance caused by the rebounding of radar waves in the vessel next wave is called return sea. In calm sea conditions, the absence of this shock wave does not occur. Logically the disturbance is greater the larger the waves. The control for the suppression of this effect works by decreasing the gain of the receiver near the ship. The closer, the biggest ship is the decrease of the gain and suppression of the return of the sea. For adjustment must be careful not to set it to a value too high, trying to remove all the returning sea, because we may be also be eliminating weak echoes around the ship. Here we see a low, correct and high setting:

During the training, We emphasize that target information processing is a time-consuming but necessary process to ensure the reliability of the information output, which inevitably causes "time delay". "Target lost" and/or "target swop" cannot be unavoidable due to sensor errors or defects inherent to the information processing system.

.2 analyze the influences of errors from essential sensors on radar information, evaluate the factors that affect radar information, such as blind area, the changes of electromagnetic wave propagation, the changes of weather and sea condition, radar clutters, radar false echoes and target characteristic, etc.

Factors affecting information accuracy of radar system
A good understanding of the factors that affect information accuracy due to radar sensor errors including radar range and bearing errors, characteristics of radar antenna and transceiver, THD error, SDME error, GNSS error and AIS error.

The understanding that the environment in which the radar is operating such as radar blind sector, propagation environment changes of electromagnetic wave, changes of weather and sea state, radar clutters, radar false echoes and target characteristics and etc., affects the accuracy of the radar information.

In particular, it should be noted that the contribution of different factors to the error varies with different navigation environments, which further influences radar fix, navigation and collision avoidance decisions. For multi-radar systems, the performance of different sensors may vary, so it is important to select radar sensors in different navigation conditions and check the integrity of information at sea, for instance, the integrity of EPFS information. In the process of collision avoidance, it is necessary to communicate in time with the target vessel and stakeholders, and check and confirm the relevant information.

.3 Predict the possible faults of bridge team in radar operation, stress the importance of team management to acquire essential and complete navigational information by operating radar properly in accordance with the operating procedures.

Influence of operation techniques on radar information
Awareness of radar navigation at the management level should be developed so as to manage the bridge team effectively to obtain necessary and complete navigational information in a timely and reasonable manner in accordance with the operation procedures.

"Keeping the best radar image" is the basis of improving the accuracy of radar information, and to keep calm when on duty and keep reminding the bridge team to operate radar in compliance with the requirements, to adjust or set it up in line with radar operating environment and tasks.

The integrity of radar information may be affected seriously in case of improper or careless operation. Therefore, the bridge team should be reminded to pay attention to important matters, for example, increasing Gain properly when the target is small, decreasing Gain properly when measuring the target, applying SOG in navigation, applying STW in collision avoidance, and noting the do's and don'ts for tuning and detuning to locate SART during SAR operations.
It should be particularly cautioned that scanty radar information is harmful to the safety of navigation.

Case study, simulator demonstration and class discussions are recommended for effective teaching and learning**.**

.4 Analyze the influences of characteristics of radar presentations and limitations on radar watchkeeping, observation, position fix, navigation, collision avoidance decision-making; assess the countermeasures to be taken.

The characteristics and limitations of radar, and countermeasures to be taken in various conditions and situations, by analyzing and discussing typical navigational scenarios and case studies. This will help OOWD at the management level to enhance not only their fundamental theory and practical knowledge but also good operational skills, so that they are able to cope with emergency situations with professional skills and judgment, as well as a stable mindset.

During the training, We refer to model course 1.07 on radar performance, and explain to trainees the need to analyze the performances of radar detection and target presentation. It should be made clear that as an active detection equipment, radar can be used to observe all surface targets around own ship including shorelines and acquire a full picture of the prevailing traffic situation. Furthermore, as one of the most important navigational instruments, radar information could be accepted as evidence in a maritime investigation.
In addition, by referring to related contents in model course 1.07, Instructors should explain clearly, the sensor limitations of a radar system including radar, AIS, EPFS, SDME, THD and ECDIS that could be imposed on look-out, observation, position fixing, navigation and collision avoidance. For example, sensor errors will reduce the accuracy of radar detection, and clutters and shadow sectors may also influence target observation. Similarly, the limitation of

target tracking reliability may present acquisition errors, omissions, target swop and loss. The size of radar screen determines the capacity of screen information, and the processing delay will increase data error. Trainees should be well aware that misinterpretation of the radar information may impose threats to safe navigation.

1.3 Awareness of radar working conditions

The optimum working condition of a radar system is the key prerequisite for acquiring accurate radar navigational information. Trainees should not only understand the fundamental theory of radar and operate it professionally, but also develop a keen sense of awareness, as well as prompt and proper assessment for radar working states.

The optimum working condition of a radar system depends on the working state of its system hardware and operational skills of the radar operator. A management level trainee should not only be able to assess radar working states and detection ability through simple instructions or procedures, but also be able to assess using their experience, the ability of the bridge team at the operational level through effective team management. OOWD should improve their radar application ability on the basis of knowledge, understanding and proficiency (KUPs) at the operational level, and accumulate sufficient experience in actual radar application, and further improve their competency through this course.

.1 Appraise abnormal operation of the radar system in reference to the "Scope of equipment" requirements of the IMO radar performance standards.

The normal operation of a radar system should be able to meet the requirements of performance standards on "Scope of equipment" provisions. In other words, it shows the position of other surface craft, obstructions and hazards, navigation objects and shorelines in relation to own ship. The following functional requirements should be discussed in detail:
- in coastal navigation and harbour approaches, by giving a clear indication of land and other fixed hazards;
- in a ship-to-ship mode for aiding collision avoidance of both detected and reported hazards;
- in the detection of small floating and fixed hazards, for collision avoidance and the safety of own ship; and
- in the detection of floating and fixed aids to navigation.

A competent management level seafarer should be able to perceive the abnormal working condition of a radar system as per the abovementioned requirements.

.2 Generalize the complexity of radar system; analyze the influence of radar equipment on the normal operation and radar information output.

Trainees at the management level should be fully aware that the radar system is a complex navigational information processing system composed of sensors and information processing instruments. A sound basic radar sensor is primary for the radar system. Poorly configured sensors will affect the quality of information output and even the normal operation of the radar system.

The following should be highlighted during the training:
- The magnetron is a key element and it affects the lifespan of a pulse radar system. The normal life of a magnetron is 4, 000 to 20, 000 hours. The larger the output power, the shorter the life of the magnetron. The performance of a magnetron degrades gradually with working hours, which is a process of slow ageing. A designated officer (second officer or electro technical officer) should be responsible for the regular maintenance in line with IMO radar performance standards and radar manufacturer's manuals. Maintenance work should be recorded in a radar logbook.

- Adverse working environment at sea causes salt rime and impurities adsorbed on the antenna radiation window, which affects echo quality. The chief mate should make arrangements for regular cleaning.

- Loss of sensor signals affects the functioning of the radar system. Instructors should emphasize that other sensors, besides the radar sensor, are also important to ensure the normal operation of radar system. In accordance with resolution MSC.192(79) IMO performance standards for radar, radar can only be operated at the unstabilized H-up presentation mode in case of faulty THD/gyro. In this situation, system sensors other than the radar sensor cannot be involved in information processing. Therefore neither the ARPA/TT and AIS target reporting function, nor the ECDIS and radar image overlay function will work.

- Meanwhile, some functions based on modern digital information processing, such as echo average, echo expansion, sweep correlation and automatic clutter depressing, which provide safe navigation information only in a stabilized presentation mode, will be greatly limited or not even functioning. If the SDME malfunctions, although the speed of own ship can be inputted manually, a big error is inevitable. This leads to the error of radar information output and therefore affects the safety of navigation.

.3 analyze the adverse effects of human element on working conditions and function of the radar system due to inappropriate setup and operation; appraise radar working conditions using effective team management skills and good radar application experience.

At the management level should develop familiarity with the functions and the information available in normal working condition. In any case, effective team management skills and good radar use experience should be applied to appraise the working state of a radar system. In teaching, attention should be drawn to the following:

.1 to emphasize the importance of verifying the integrity of the primary navigation data including time, position, course and speed for the optimum navigational information. In particular, the significance of the integrity indication of GPS to the accuracy of AIS information, the association of radar tracking and AIS reporting targets, and the accuracy of ECDIS and radar image overlay should be explored intensively;

.2 to study cases regarding how to obtain high quality radar image using gain, tuning and clutter suppression comprehensively and to assess the performance of the radar operator and the working conditions of the radar system by evaluating echo quality;

.3 to explore the necessity of timely switching between STW and SOG for different navigation tasks and specific navigation needs, as well as the limitations of different SDME sensors, and to emphasize the harmfulness of careless or unconscious radar operation to obtaining the best navigational information; and

.4 to improve trainees' ability to appraise situations and collision danger, and the ability to make collision avoidance decision with the support of comprehensive analyzes of trail, manual plotting information, automatic plotting information, AIS reported information and the association of TT/AIS information according to navigation safety needs.

Practical training 1 - Awareness of radar working conditions

.1 Training objectives

This training provides an indispensable link to the learning objectives of this chapter. It aims to help trainees to establish familiarity with factors affecting the reliability and accuracy of radar information, to understand well the radar performances and limitations, and to improve their awareness of radar working conditions, thus laying a solid foundation for decision-making by using radar information properly in navigation.

.2 Training contents

Trainees operate the function controls/menu such as gain, tuning, clutters suppression and information processing, etc. for high quality radar echoes. Then, radar working conditions are to be evaluated by echo quality, and the competence

of the radar operator at the operational level in the bridge team is to be assessed as well.
The integrity of sensor information, the associated effect of radar tracking target and AIS reported target and the overlying accuracy of electronic navigation chart and radar echo, should be explored so that the ability for determining the reliability and accuracy of the radar information can be enhanced.
The influence of radar system partial malfunction on radar information is to be evaluated by setting loss of sensor signals.

.3 Training strategies

1. Trainees should complete the training programs for typical conditions and scenarios set up by Instructors in a real radar, or a radar training simulator.
2. It is recommended that acquiring of high quality radar echoes, evaluating the accuracy of radar information, and identifying radar working conditions, should be included in the training course.

.4 Discussion and review
Upon completion of the training, Instructors should organize a discussion for trainees to share their experience, knowledge gained and any queries, followed by comments, solutions to problems and revisiting any of training highlights.

2. USE OF RADAR NAVIGATION

2.1 MAKING A VOYAGE PLAN.

.1 Manage the bridge team , evaluate and select radar targets when making a voyage plan taking into account avoiding risks , improving accuracy , and highlighting the limitations and aiming at sage navigation

A passage plan is a comprehensive, berth to berth guide, developed and used by a vessel’s bridge team to determine the most favourable route, to identify potential problems or hazards along the route, and to adopt Bridge Management Practices to ensure the vessel’s safe passage.
The purpose of voyage planning is to develop a comprehensive navigation plan for the safe conduct of the ship from berth to berth. It is directly related to safety of life at sea, safety and efficiency of navigation, and protection of the marine environment during the intended voyage or passage. Every effective means should therefore be taken by personnel at the management level to make sure that the voyage plan is carefully prepared and reliably executed. Among the numerous factors to consider in planning a voyage, radar navigation has become an indispensable element in the whole process, thanks to the improved modern radar performance standards and added functions.

Personnel at the management level should make full use of all available resources and means in the supervision of the bridge team to prepare a voyage plan. Particularly for this course, due regard should be given not only to the benefits in the use of radar in position fixing, navigation and hazards avoidance, etc., but also to the limitations of the radar system. Hence, optimum schemes for navigation and monitoring can be adopted in all waters, particularly in coastal waters, restricted waters, areas with extreme weather conditions such as restricted visibility, ice-infested waters, traffic separation schemes (TSS) and vessel traffic service (VTS) areas, to ensure safe navigation to the maximum extent possible.

Master and Chief mate at management level should emphasize the principles and cautions for target selection. For the benefit of navigation safety, Instructors should develop trainees' awareness of prudently managing assessment of the voyage plan for safe navigation in terms of risk avoidance, improving accuracy and consciousness of limitation; taking into account such fators as: the navigational mission, characteristics of selected and back-up radar targets, convenience and precision of radar position fix, safety margin of risk avoidance, and multi-source information integration and adopt a critical attitude and make critical judgments so that they are able to identify risks of poor or wrong radar targets, and be able to explore a variety of applications for conspicuous radar targets.

Passage planning includes a complete description of the ship's passage which is prepared by an experienced deck officer of the ship. This is done to ensure that the ship sticks to the required routes for reaching the port of destination.
A ship's passage planning involves 4 major steps/stages. They are as follows:

- Appraisal
- Planning
- Execution
- Monitoring

Each stage in the passage planning has its own importance and it is extremely important to carry out each one of them with utmost care and up-to-date seamanship to ensure a safe sail.
In the start, a rough estimate is made of the whole sailing process. Once the rough plan is ready, it is further tweaked and modified/refined considering various details obtained from charts, pilot book, weather routing etc. These processes are carried out throughout the appraisal and planning stages.
In the next two stages i.e., execution and monitoring, the plan is used as a guideline, and the sailing is executed taking into consideration various factors, both observed and predicted.
Each aspect of passage planning has been explained in detail below:

Appraisal
In this stage, the master of the ship discusses with the chief navigating officer (usually the Second Mate), as to how he intends to sail to the destination port. (In some cases it may be required for the master to plan the passage). This is the process of gathering all information relevant to the proposed passage, including ascertaining risks and assessing its critical areas. This involves information extracted from publications as well as those within the chart. The appraisal will include details from:

- Chart Catalogue
- Charts
- Ocean Passages of The World
- Routeing Charts
- Admiralty Sailing Directions
- Admiralty List of Lights and Fog Signals
- Admiralty List of Radio Signals
- Tide Tables
- Tidal Stream Atlas
- Notices to Mariners
- Admiralty Distance Tables
- Ships Routeing
- Navigational Warnings
- Mariner's Handbook
- Load Line Chart
- Draft of Ship
- Owners and other sources
- Personal Experience

Taking into consideration master's guidelines, company's guidelines, ship's cargo, marine environment, and all other factors that may affect the ship, the navigating officer draws upon a general track, which the ship shall follow.
For the ease of planning, this plan is first laid out on a small scale chart, which is later transferred to larger scale charts, and then minor modifications are made as and when deemed necessary.
Planning

Having made a full appraisal using all information at hand pertaining to the passage, the OOW, under the authority of the Master is to prepare a detailed plan for the passage. In this stage, the intended courses of the ships are actually laid out on the charts of suitable scale and all additional information is marked. The plan is laid out from pier to pier, including the pilotage waters.

It is a good practice to mark dangerous areas such as nearby wrecks, shallow water, reefs, small islands, emergency anchorage positions, and any other information that might aid safe navigation.

In addition to the above-mentioned things, is it advisable to layout the rate of turn for waypoints and laying out of PI ranges for suitable objects, if any.
Reporting areas should also be clearly marked on the charts. Elements of the Planning phase include:

- No-Go areas
- Margins of safety
- Charted Tracks
- Course alterations and wheel over points
- Parallel Indexing
- Aborts and Contingencies
- Clearing line and bearings
- Leading lines
- Tides and current
- Change in engine status
- Minimum UKC
- Use of Echo Sounder
- Head Mark
- Natural Transit

Aborts: When approaching constrained waters, the vessel might be in a position beyond which there is no possible action but to proceed. For example, the vessel enters an area so narrow that there is no room to return. It is for this purpose that a position is drawn on the chart showing the last point wherein the passage can be aborted.
Contingencies: The bridge team must always be aware that the events might not go as planned and that emergency action might be required. Contingency plans account for such situations, clearly shown on the chart so that the OOW can take swift action in such a jam. Contingency planning will include alternative routes, safe anchorages, waiting areas, emergency berths.

Execution
In this stage, the navigating officers execute the plan that has been prepared. After departure, the speed is adjusted based on the ETA and the expected weather and oceanographic conditions. The speed should be adjusted such that the ship is not either too early or late at its port of destination. The Master should find out how long his intended voyage is, accounting for water and fuel available. Also to be taken into account are any expected weather changes along the way. In case and ECDIS is being used, appropriate limits must be set with regard to the safety settings.

Monitoring
Monitoring is that aspect which takes into account checking of the position of the vessel, such that it remains within the safe distance from any danger areas. Parallel Indexing can be used to maintain safe distance alongside any hazards to navigation. A safe and successful voyage can only be achieved by close and continuous monitoring of the ship's progress along the pre-planned tracks. Situations may arise wherein the navigating officer might feel it prudent to deviate from the plan. In such case, he shall inform the master and take any action that he may deem necessary for the safety of the ship and its crew. This stage is a very important stage wherein all the deck officers contribute their part to execute the plan. This calls for personal judgement, good seamanship and experience.

.2 Selection suitable radar targets and fixing methods and assess the accuracy of the resulting fix considering circumstances , limitations of radar and bridge resources

For the safety of navigation, it is necessary that the ship's position should be monitored continually at appropriate intervals using two or more independent position fixing systems appropriate to the waters. Besides fixing by landmarks or other visual marks, dead reckoning, GPS positioning, etc. radar position fixing as a reliable, intuitive, accurate, convenient method is widely adopted in planning and executing a voyage.

The radar is one of the most used equipment systems onboard ships. It is designed for detecting and tracking targets a considerable distance. Needless to say, it's of great practical value to the navigators.

Therefore the radar navigational factors should be fully taken into account in the supervision of voyage plan preparation by personnel at the operational level. Instructors should focus on the specific skills to choose appropriate radar fixing methods and the correction methods to obtain accurate position fixing on different occasions, in different water areas and other specific conditions. A thorough analysis should be conducted regarding the various methods of radar position fixing such as position fixing by cross bearings, by ranges, and mixed fixing by ranges and bearings in terms of their respective procedures, advantages, limitations, reliability, sources of error, etc.

Master and Chief mates at management level should highlight the errors of position fixing by radar means, including faults, systematic errors and random errors, and their causes and characteristics. To meet competence requirements in the STCW Convention, as amended, relating to "specific knowledge of their operating principles, limitations, sources of error, detection of misrepresentation of information and methods of correction to obtain accurate position fixing", trainees should attain knowledge and skills in:
.1 analyzing, determining and processing various errors; and
.2 applying appropriate observation methods or techniques to obtain more accurate position fixing based on available data, and develop a good understanding of the resulting fix.

For example, appropriate estimation of the resulting fix by 2 lines of position (LOPs) eliminating the random errors and systematic errors; reasoned judgment about the cocked hat when 3 LOPs are taken, and the most probable position (MPP), based on the theory of navigational errors; and the ability to analyze, assess and correct composite errors considering such factors as wavelength radars, weather, sea conditions, sitting radar units, antenna height, the distance to radar target, etc.
Proper use of radar and radar plotting aids in both restricted visibility and clear weather can help prevent collisions and ensure the safety of the ship. Accidents can occur if the watch keeping officer is not fully conversant with the operation of the equipment. For reliable interpretation, it is essential that the radar operating controls be adjusted properly.

A radar operates by radiating electromagnetic energy and detecting the echo returned from reflecting objects (targets). The nature of the echo signal provides information about the target

If the target is moving, a radar can derive its track, or trajectory, and predict the future location. The shift in frequency of the received echo signal due to the doppler effect caused by a moving target allows a radar to separate desired moving targets (such as aircraft) from undesired stationary targets (such as land and sea clutter) even though the stationary echo signal may be many orders of magnitude greater than the moving target. With sufficiently high resolution, a radar can discern something about the nature of a target's size and shape.

Radar is an active device in that it carries its own transmitter and does not depend on ambient radiation, as do most optical and infrared sensors. Radar can detect relatively small targets at near or far distances and can measure their range with precision in all weather, which is its chief advantage when compared with other sensors.

A radar generally determines the location of a target in range and angle, but the echo signal also can provide information about the nature of the target.

Although the name radar is derived from radio detection and ranging, a radar is capable of providing more information about the target than is implied by its name. Detection of a target signifies the discovery of its presence. It is possible to consider detection independently of the process of information extraction, but it is not often that one is interested in knowing only that a target is present without knowing something about its location in space and its nature. The extraction of useful target information is therefore an important part of radar operation.

Marine radar is radar that is mounted and used by ships at sea for collision avoidance and other uses. It is used to detect other ships at sea and any other land obstacles. It is one of the most important safety components at sea and near the shores. But like all radar systems, marine radar has its own limitations and errors. Below are some of the errors and limitations.

Errors

1. Index error: This is the difference between the actual range between two points on a map and the range detected by the radar. This error can be observed when the vessels seats abeam between two points.
2. Beamwidth error: When the radar beam from the vessels moves away from the vessel, the width of the beam tends to widen. This causes distortion of the objects being detected. This distortion error increases as the vessel moves further away from the vessel.
3. Attenuation error: Attenuation is caused by the absorption and subsequent scattering of the beam energy as it is transferred through the atmosphere. This usually leads to a significant reduction in the strength of the echo. Attenuation is more pronounced in instances where there is a high frequency and short wavelengths.
4. Double echoes: These happen when the radar signals bounces off some parts of the ship and back into the receiver.
5. Multiple echoes: Multiple echoes occur as a result of several reverberations of the echoes from a different ship and from own ship multiple times. The display screen may show more than two or three objects being detected.
6. Indirect wave error: When a radar beam is emitted from the vessel, it is supposed to travel in a straight line direct to the contact. However, there are instances where

the beam falls into the sea and it is deflected further which makes it travel a longer distance than if it would have travelled in a straight line.

Limitations

1. Clutter: Radar signals are affected by clutter especially from the sea and those caused by rainfall. This is why clutter controls are provided. However, the clutter controls need to be used with great caution because they may end up suppressing weaker objects that are navigating within the clutter zone.
2. Blind/Shadow sectors: The structure of the ship and sometimes the objects on the ship may cause blind or shadow sectors on the ship. For this reason, it is important to properly mark the shadow or blind sectors in order to let other users understand the limitations of these sectors.
3. Distorted coastline: When a vessel is approaching a straight coastline, the radar may report a curved coastline or vice versa. This is because of the distance the radar takes to reach and return to the receiver from areas that are further away from the centerline of the vessel.
4. Input limitations: There are a number of sources that are used to feed information into modern radars. Some of these sources include GPS and compasses. These inputs may also have their own limitations that may have an effect on the radar itself. Ship navigators should be aware of these input limitations so as to understand their effect on the radar.
5. Heading misalignment: Heading markers are usually manually set on the radar on a vessel. This means that the markers may end up being misaligned for one reason or the other. To ensure the heading marker is not misaligned, you will need to point two vessels directly at each other. Ensure they are at a safe range. Once you have the vessels at this position, take the bearing of your vessel using a compass. The heading marker needs to correspond to this bearing.
6. Bearing discrimination: The radar set on the vessel needs to be able to distinguish between two different targets of the same range but with slightly different bearings. The radar is not able to discriminate and differentiate between these two contacts and may report as the same.

Factors Affecting Radar Performance

The performance of a radar system can be judged by the following:

(1) the maximum range at which it can see a target of a specified size,
(2) the accuracy of its measurement of target location in range and angle,
(3) its ability to distinguish one target from another,
(4) its ability to detect the desired target echo when masked by large clutter echoes, unintentional interfering signals from other “friendly” transmitters, or intentional radiation from hostile jamming (if a military radar),
(5) its ability to recognize the type of target, and

(6) its availability (ability to operate when needed), reliability, and maintainability.

Detection

Where a separate facility is provided for detection of targets, other than by the radar observer, it should have a performance not inferior to that which could be obtained by the use of the radar display.

Acquisition

Target acquisition may be manual or automatic for relative speeds up to 100 knots. However, there should always be a facility to provide for manual acquisition and cancellation: ARPA with automatic acquisition should have a facility to suppress acquisition in certain areas. On any range scale where acquisition is suppressed over a certain area, the area of acquisition should be defined and indicated on the display.

Automatic or manual acquisition should have a performance not inferior to that which could be obtained by the user of the radar display.

Tracking

The ARPA should be able automatically to track, process, simultaneously display and continuously update information on at least 20 targets, whether automatically or manually acquired.

If automatic acquisition is provided, description of the criteria of selection of targets for tracking should be provided to the user. If the ARPA does not track all targets visible on the display, targets which are being tracked should be clearly indicated with the relevant symbol* on the display. The reliability of tracking should not be less than that obtainable using manual recordings of successive target positions obtained from the radar display.

The ARPA should continue to track an acquired target which is clearly distinguishable on the display for 5 out of 10 consecutive scans, provided the target is not subject to target swop.

The possibility of tracking errors, including target swop, should be minimized by ARPA design. A qualitative description of the effects of error sources on the automatic tracking and corresponding errors should be provided to the user, including the effects of low signal-to-noise and low signal-to-clutter ratios caused by sea returns, rain, snow, low clouds and non-synchronous emissions.

The ARPA should be able to display on request with relevant symbol* at least four equally time-spaced past positions of any targets being tracked over a period appropriate to the range scale in use. The time-scale of the past position plot should be indicated. The operating manual should contain an explanation of what the past position plots represent.

Fixing By placing

The simulated range ring transparency over the chart so that the simulated rings have the same relationship to charted objects as the actual range rings have to the corresponding echoes, the observer's position is found at the center of the simulated range rings. Under some conditions, there may be not be enough suitable objects and corresponding echoes to correlate with the range rings to obtain the desired accuracy. This method of fixing should be particularly useful aboard small craft with limited navigational personnel, equipment, and plotting facilities. This method should serve to overcome difficulties associated with unstabilized displays and lack of a variable range marker.

Preferably, radar fixes obtained through measuring the range and bearing to a single object should be limited to small, isolated fixed objects which can be identified with reasonable certainty. In many situations, this method may be the only reliable method which can be employed. If possible, the fix should be based upon a radar range and visual gyro bearing because radar bearings are less accurate than visual gyro bearings. A primary advantage of the method is the rapidity with which a fix can be obtained. A disadvantage is that the fix is based upon only two intersecting position lines, a bearing line and a range arc, obtained from observations of the same object. Identification mistakes can lead to disaster.

.3 Selection and asses radar navigation objects and methods considering circumstances, limitations of radar and bridge resources
This is the preferred method when fixing the position by radar observations. Ranges taken from the radar are generally more accurate than radar bearings. Avoiding the steps necessary to convert relative or compass bearings to true also reduces the chance of error.

Master and chief mates at management level should pay attention to the following issues when providing guidance to OOWD to assess voyage planning:
.1 all radar-conspicuous targets, for example, RACONs, near the intended track should be fully considered;
.2 PI lines should be reasonably marked on the radar, and risks resulting from an unstablized radar presentation should be noted; and
.3 multiple PI lines or navigation lines should be reasonably used to assist course alterations, noting the difference between large and small ones.

When presenting the method using maps, navigation lines and routes for radar navigation, Instructors should highlight the limitations and risks of the method, for example, errors in relative and own ship's positions, if transferred to maps and route information, may result in incorrect and misleading displayed information or even accidents; the existence of navigation lines may affect the identification of small and weak radar targets; and the accuracy of this navigation method is affected by the error of the SOG (speed over ground) sensor.

For example, one way of monitoring the validity of the navigation lines is to use some lines or points to represent fixed features that can be easily recognized on the radar such as breakwaters, lengths of coastline, or just buoys or light vessels. In addition, a SOG sensor of higher accuracy can be selected to improve the navigational accuracy when using this method.

The method of "Electronic chart and radar picture overlay for radar navigation". In relation to voyage planning for navigation in particular waters, making full use of the advantages of overlay function, OOWD should, select the appropriate radar navigation target, and design appropriate navigation methods, such as the methods of navigation by use of buoys, transit marks, and leading marks. Proper alarms, for example sounding alarm and XTE alarm, should also be selected.

Ranges must be taken off the adjacent latitude scale and the relevant arc plotted on the chart using compasses. Both ends of the arcs should be marked with a single arrow, the point of intersection circled, and the time of the fix written alongside.

Selection of objects for ranges is as important as it is with bearings, and any cocked hat should be treated in much the same way.

By Combined Range and Bearing

When only one suitable object is available the position may be fixed with a single bearing of that object combined with its range. Although the range would usually be measured by radar it is still preferable to obtain the bearing visually. The bearing can usually be taken more accurately by visual means.
By a Bearing and Sounding

This method may be used providing:

· Allowance is made to reduce the sounding to chart datum.
· The depth contours are well defined.
· The contour in question only crosses the position line in one possible place.
· The depth contour crosses the position line at a wide angle.

.4 Selection and assess of reference radar navigation objects and methods to keep clear of dangers considering circumstances, limitations of radar and bridge resources

Radar provides a reliable, accurate method of passing safe distance off danger areas, and contributes to the simple and reliable execution of a voyage plan. Therefore, it is necessary for efficient operation to select appropriate radar-assisted methods to keep clear of dangers in passage planning. Key point for such methods is the identification of navigational dangers and the choice of reference objects to keep clear of dangers. This also provides the basis for the selection of radar-assisted methods to keep clear of dangers in various circumstances and conditions.

Management level officers have utilize the following information or resources in a more effective and comprehensive manner: large scale charts of current edition, sailing directions, the latest notices to mariners and navigational warnings, tide data, own ship radar performance, draft restrictions, requirements of under keel clearance (UKC), the company's ISM Code requirements, etc.; and to identify and interpret the potential dangers in the vicinity of the intended route, in addition to land, islands and other land targets ranged by radars; hazardous objects or areas which are not radar-detectable, such as wrecks, shoals, reefs, obstruction areas, military exercise areas, inaccurate sounding areas and other waters doubtful with regard to safe navigation.

With a thorough understanding of the abovementioned navigational dangers, officers should have knowledge of the principles, methods, and cautions for selecting the reference objects (mostly radar conspicuous targets) to keep clear of dangers by the use of radar, and the specific knowledge of reasonably using the method of electronic chart and radar picture overlay to ensure ship safety where no proper reference objects are available, by choosing appropriate radar-assisted methods to keep clear of dangers, which may include radar PI clearing ranges, circular clearing ranges, and clearing bearings, according to the particular feature of danger areas, the positional relationship between the reference objects and intended track, as well as specific water conditions, own ship manoeuvring characteristics, and skills of the bridge team. The applicable conditions, key points of danger clearing, limitations and cautions of these methods should be emphasized and analyzed comprehensively

For many decades, radar has been a good friend of the navigator. Radar has been our eyes in the dark and restricted visibility and has allowed us to see, if not identify, targets that could be navigational hazards, or assist us with position fixing. It does not depend on the correct operation of external systems, such as GPS – and that is why we trust it.

Radar found its way onto merchant ships after the Second World War as an early electronic aid. Use of it grew slowly and with caution. In the 1960s, as radar became

more common, radar-assisted collisions became a reality and, for the first time ever, equipment-specific training and revalidation was introduced by the IMO.
In more recent decades, radar has improved remarkably with enhanced filters for clutter, effective auto tuning, color displays and the benefits of new technology radar on S-Band.

For many navigators, however, the true value lies in the fact that radar is largely autonomous and shipcentric.

So many of our current navigation aids (GPS, GNSS, Loran, AIS, etc.) are reliant on external sources that can be interrupted, intentionally or unintentionally.
Yet radar is trusted, as the pulse is generated by the ship for the ship and has proved to be highly reliable.

Modern radar returns very accurate images of targets and can be enhanced with many additional tools, such as trial manoeuvres, AIS, chart overlay/underlay, and the tried-and-tested ARPA.

A comprehensive understanding of the functionality and reliability of radar and these enhancements is therefore essential for navigators.

This issue of The Navigator is dedicated to radar and its onboard use. Radar is an essential tool for safe navigation and improving situational awareness.

Its use should be balanced with visual observation (in other words, looking out of the window), ECDIS and the many other available aids to navigation. Radar should, however, also be appreciated for its independence and reliability.

Modern radar can be highly sophisticated and, in addition to any generic radar training that navigators receive, there is a real need for ship-specific radar familiarization as specified in the ISM Code.

Radar can be your best friend in reduced visibility. So learn how to use it effectively, how far to trust it and how to balance its use with all the other aids to navigation.
Most of all – the windows!

There are two clear and distinct purposes for which radar is used; navigation and collision avoidance.

While there are some fundamentals of radar use that are the same for both tasks, the ideal radar set-up for the two tasks is quite different. In fact, if there are two radars available, it may well be advisable to use one radar for long-range and one for close-range detection, or one for navigation and one for collision avoidance

Although there are clear best practices on setting up a radar for collision avoidance purposes, the tools you use and the way you manage the display can be based on personal preference or local conditions. For example, the situation can be very different if you are in a crowded waterway from when a vessel is on the open sea.

Radar can help with collision avoidance in many ways. The simplest, perhaps, is to lay an electronic bearing line (EBL) across a suspected target to see if the relative bearing is steady and if a risk of collision exists.

2.2 Executing a voyage plan

.1 **Executing a voyage plan in coastal and narrow channel waters to ensure safety of navigation by managing bridge resources effectively, by supervising the watchkeeping resources effectively , by supervising the watchkeeping officer´s radar operation , by evaluating radar information prudently , and by utilizing radar resources properly and effectively**

To ensure good management of radar resources for safe navigation in coastal and narrow waters, officers at the management level should be required not only know how to operate radar, but also be responsible for monitoring and supervising radar operations by watchkeeping officers.
Highlighting the varieties of radar interference noises, multiple sources of radar information and the limitations of radar equipment, officers should be able to manage bridge resources in specific conditions, supervise the proper operation of radar and understand the radar information provided by watchkeeping officers. They should be able to make proper use of radar resources to ensure safety in case of emergencies.
Executing a voyage plan in coastal waters
Officer at mangement and operational level should:
.1 develop familiarity with the methods and skills of position fixing, navigation and risk avoidance by various natural or/and artificial landmarks, and be capable of providing due supervision and support to watchkeeping officers;
.2 be aware of the peculiarities of radar interference noises in coastal waters and be able to recognize, in a timely manner, the features and risks of identifying wrong radar marks;
.3 be familiar with methods of rectifying such wrong identification with appropriate adjustment made to gain, brilliance, interference clutter, pulse width, display mode, and comparison with charts, and ways to identify radar targets by referring to the possible positions and using the ECDIS-RADAR overlay function;
.4 take notice of the limitation of the offset scope and availability of conspicuous radar marks when navigating along coastal waters. Position fixing and navigation by radar are recommended to examine the reliability of GPS position for safe navigation;

.5 develop an understanding of the causes, influencing factors, accuracy limitation;
.6 develop familiarity with methods of error analysis to acquire a more accurate vessel position and to verify and monitor the position at suitable intervals by referring to electronic position fixing, position fixing by landmark and track estimation;
.7 learn to evaluate and supervise the watchkeeping officers in using the methods of radar navigation and risk avoidance in voyage planning and in setting the key parameters and display with respect to leading line, PI index and risk avoidance line etc.;
.8 understand the limitations and risks of radar navigation and risk avoidance with recognition of such methods as a supplementary means; and
.9 understand that when navigating in coastal waters, risk avoidance can also be achieved by selecting small isolated landmarks which are easy to be identified as reference objects. In this case, a CPA that is no less than the range for risk avoidance should be maintained while keeping the vessel's course over ground and tracking the radar target by ARPA/TT.
Remember to prepare a contingency plan specifying the sailing methods, risks and precautions for each leg of the voyage. Due to restricted manoeuvrability in narrow waters, there could be more consideration, evaluation and application of radar navigation and risk avoidance.
In case of shelter from shoreline in the bend areas of narrow waters where the targets might not be detected by radar, the decline of data accuracy, the risks of false echo, same frequency interference and index line may affect the reliability and accuracy of radar information, thus imposing negative effects on radar navigation and risk avoidance.
Before transiting hazardous waters, the prudent navigator should develop a feasible plan for deriving maximum benefit from available navigational means. In developing his plan, the navigator should study the capabilities and limitations of each means according to the navigational situation.
He should determine how one means, such as cross-bearing fixing, can best be supported by another means, such as fixing by radar-range measurements. The navigator must be prepared for the unexpected, including the possibility that at some point during the transit it may be necessary to direct the movements of the vessel primarily by means of radar observations because of a sudden obscurity of charted features. Without adequate planning for the use of radar as the primary means for insuring the safety of the vessel, considerable difficulty and delay may be incurred before the navigator is able to obtain reliable fixes by means of radar following a sudden loss of visibility.

An intended track which may be ideal for visual observations may impose severe limitations on radar observations. In some cases a modification of this intended track can afford increased capability for reliable radar observations without unduly degrading the reliability of the visual observations or increasing the length of the transit by a significant amount. In that the navigator of a radar-equipped vessel always must be prepared to use radar as the primary means of navigating his vessel while in pilot waters, the navigator should effect a reasonable compromise between the requirements for visual and radar fixing while determining the intended track for the transit.

The value of radar for navigation in pilot waters is largely lost when it is not manned continuously by a competent observer. Without continuous manning the problems associated with reliable radarscope interpretation are too great, usually, for prompt and effective use of the radar as the primary means of insuring the safety of the vessel.

The continuous manning of the radar is also required for obtaining the best radarscope presentation through proper adjustments of the operating controls as the navigational situation changes or as there is a need to make adjustments to identify specific features. With radar being used to support visual fixing during a transit of hazardous waters, visual observations can be used as an aid in the identification of radar observations. Through comparing the radar plot with the visual plot, the navigator can evaluate the accuracies of the radar observations. With radar actually being used to support visual fixing, the transition to the use of radar as the primary means can be effected with lesser difficulty and with greater safety than would be the case if the radar were not continuously manned and used to support visual fixing.

While the navigational plan must be prepared in accordance with the manning level and individual skills as well as the navigational situation, characteristics of navigational aids or equipment, characteristics of radar propagation, etc., the navigator should recognize the navigational limitations imposed by lack of provision for continuous manning of the radar.

A transit, which may be effected with a reasonable margin of safety if the radar is manned continuously by a competent observer, may impose too much risk if provision is not made for the continuous manning of the radar. The provision for continuous manning of the radar by a designated and competent observer does not necessarily mean that other responsible navigational personnel should not observe the radarscope from time to time.

There is a reason as to why a separate rule is dedicated to ship navigation with respect to narrow channels (and fairways). A ‘channel’, by obvious measure, is a natural or dredged water body with shallow waters on either sides, normally marked by buoys.

A ‘fairway’ pertains to the same in open water, wherein the depth of water on either sides might not be shallow. The term ‘narrow’ is applied to the former having had due regard to the nature of the vessel (length, draft etc.) and other circumstances relevant to the water body, i.e, it is subjective.

Just as it is for navigation in any waters and condition of the vessel, these specific waters pose considerable dangers to the safety and safe navigation of any vessel.

Due caution is to be exercised when transiting narrow channels for it entails limited sea room and surrounding threats that might be detrimental to the transit.
Prevailing/ Expected Traffic

The density of traffic is obviously going to be a lot more as compared to that in open sea. With lesser room and sizeable vessels, the risk of collision automatically increases exponentially, relatively speaking. The duty officer must exercise due diligence while in transit, posting lookouts on the bridge wings as well as keeping a “hawkish” watch on the radar as well. One must ensure that the vessel adheres to the Rules of the road in determining the actions that might have to be taken as well as the rule that is to be stuck to when in a narrow channel. That is to say, Rule No. 9 of the ROR must be followed for the safety of vessel as well to avoid any legal implications, if situation arises.

.2 Execute a voyage plan in TSS and VTS waters to ensure safety navigation by managing bridge resources effectively , by supervising the watchkeeping officer´s radar operation, by evaluating radar information prudently , and by utilizing radar resources properly and effectively

One of the best practices to avoid any mishap while transiting a narrow channel is to have a crystal clear communication setup with the VTS (vessel traffic services). They have a clear idea and system in place with regard to the transit, to and fro, of every vessel, in the zone of concern. Following their instructions and conveying the requirements of the vessel ensures smooth operations on both ends and therefore, a smooth transit.
Reminded to make full use of radar information to identify the shoreline, islands, capes and Racon, and to locate the entrance and termination point of TSS. Radar image in combination with the information provided by ECDIS and AIS may be used to identify buoys, traffic lanes, separation zones or lines, roundabouts, inshore traffic zones, precautionary areas, no go areas, etc., for safe navigation in the recommended routes.
The importance of familiarity with the start and termination points of VTS reporting lines. They should make sure that the watchkeeping officers are capable of making remarks and warning alarms of reporting points on radar maps. Radar position fixing function can also be used to locate the start and termination of the reporting points, the limitation of which, however, should be noted.
Management level officer must be aware of the peculiarities of navigation in VTS waters and should be able to manage bridge resources and supervise the setting up of radar and the proper understanding of radar information, paying due attention to the possible interferences of false echoes. The radar map can be overlaid in combination with the information provided by ECDIS and AIS to assist safe navigation.
Capabilities in identifying navigational hazards and obstructions. Officers should also be capable to identify navigational aids abnormalities, obstacles, derelict and all

other abnormalities hindering safe navigation by all available means, and to promptly report such cases to the appropriate VTS centre. At the same time, isolated danger marks and cardinal marks should be correctly identified by radar, and danger areas could be avoided by using PI indexing, distance lines and bearing lines.
Bridge to Bridge communication

The VHF, for obvious reasons, stands to be an important tool in matters of communication in this aspect. Its purpose, among many, is to clarify intent to surrounding vessels, especially to those that stand to pose a danger to the safe transit of your own vessel. Navigational aids such as the AIS and the radar(s) must be used to determine the identity, positioning, CPA etc. of the vessel in question and the same must be promulgated to the target vessel(s). Usage of the SMCP if full clarity ensures that both parties understand intent very thoroughly and agrees as well as understands the decided course of action.

.3 **Execute a voyage plan in/near ice-infested waters to ensure safety of navigation by managing bridge resources effectively, by supervising the watchkeeping officer´s radar operation, by evaluating radar information prudently , and by utilizing rdar resources properly and effectively**

Insufficient use of radar might result in reduced chances of ice detection (radar should be fully used for ice detection). Arctic or cold conditions do not affect the performance of the radar system. While radar can be of great assistance in giving warning of ice, sole reliance should however, never be placed on radar for ice warning. Visual observations should always be preferred.

Development of an awareness of both the importance and limitation of radar when navigating in ice (including floating ice and icebergs) when delivering the following,
.1 Review radar reflectivity of different kinds of ice and explain the respective characteristics and changes of radar returns and their identifications in different sea conditions and from different distances;
.2 Problems encountered with position fixing arise from either mistaken identification of shore features or inaccurate surveys. Ice piled up on the shore or fast ice obscuring the coastline makes it hard to identify returns of landmarks or points of land. For this reason, radar bearing or range should be treated with more caution than in ice-free waters;
.3 Leads through ice will probably not show up on radar unless the lead is wide enough to be distinguished and free of brash ice. Shadow areas behind ice ridges are liable to be mistaken for leads;
.4 Buoys are liable to be set adrift by the force of ice, or may simply drag their moorings. They may be hidden under ice or snow or may not be on station, and sometimes may be removed by authorities during the ice season;

.5 Sea or rain clutters will suppress small ice fragments. Snow sleet and rainstorms will impair detection. The antenna may be covered with ice or snow and may not detect any signal;
.6 Icebergs may possess underwater spurs and ledges at a considerable distance from the visible portions, and should be given a wide berth at all times; and
.7 Demonstrate respective advantages and constraints of the 10 cm and 3 cm radars in detecting ice. To detect the different kinds of ice in different distances from the ship and in different sea conditions, it is necessary to set up and use radars properly in consideration of the band, the scanner's height and position;

Radar can be an invaluable aid in the detection of ice if used wisely by the radar observer having knowledge of the characteristics of radar propagation and the capabilities of his radar set. The radar observer must have good appreciation of the fact that ice capable of causing damage to a ship may not be detected even when the observer is maintaining a continuous watch of the radarscope and is using operating controls expertly.

When navigating in the vicinity of ice during low visibility, a continuous watch of the radarscope is a necessity. For reasonably early warning of the presence of ice, range scale settings of about 6 or 12 miles are probably those most suitable. Such settings should provide ample time for evasive action after detection.

Because any ice detected by radar may be lost subsequently in sea clutter, it may be advisable to maintain a geographical plot. The latter plot can aid in differentiating between ice aground or drifting and ship targets. If an ice contact is evaluated as an iceberg, it should be given a wide berth because of the probability of growlers in its vicinity. If ice contacts are evaluated as bergy bits or growlers, the radar observer should be alert for the presence of an iceberg.

Because the smaller ice may have calved recently from an iceberg, the radar observer should maintain a particularly close watch to windward of the smaller ice. ICEBERGS While large icebergs may be detected initially at ranges of 15 to 20 miles in a calm sea, the strengths of echoes returned from icebergs are only about 1/60 of the strengths of echoes which would be returned from a steel ship of equivalent size. Because of the shape of the iceberg, the strengths of echoes returned may have wide variation with change in aspect.

Also, because of shape and aspect, the iceberg may appear on the radarscope as separate echoes. Tabular icebergs, having flat tops and nearly vertical sides which may rise as much as 100 feet above the sea surface, are comparatively good radar targets. Generally, icebergs will be detected at ranges not less than 3 miles because of irregularities in the sloping faces.

.4 Execute an anchoring plan to ensure safety of navigation by managing bridge resources effectively , by supervising the watchkeeping officer´s radar operation, by evaluating radar information prudently , and by utilizing radar resources properly and effectively

Anchoring operations planning consists of information, instructions and actions which contribute to a procedure for manoeuvring the vessel to the designated anchor position and successfully anchoring in a safe, seamanlike manner taking the prevailing weather conditions and sea state into consideration.
The following will enable Officers to manage the supervision of proficient radar operation for necessary anchoring information by the bridge team in such conditions as wind, wave, current and the density of ships at anchorage for a proper anchorage choice and safe and sound arrival at the position:
.1 Determine the future anchorage and/or position for anchoring according to chart and VTS instruction;
.2 Adjust the range scale in time to adapt to the distance from future anchorage/position and the density of anchoring ships; and
.3 Monitor and measure the distance from other ships prior to dropping anchor.

Management level officers have to take full account of the following risks during, and preparations for, watchkeeping by radar after the completion of dropping anchor:
.1 Select one or several conspicuous object(s) and fix the ship's position, and record ship’s heading and GPS position at the time of dropping anchor, and then record the length of paid-out chains after anchor dropping;
.2 Supervise the bridge team to make reasonable settings on the radar based on calculation of the radius and centre of circle of anchor watch alarm considering wind, wave, current and the data mentioned in the above paragraph, and noting that there is an error of radius and centre resulting from anchor dredging and chain catenary;
.3 Draw a guard zone on radar to monitor other ships approaching in case of dragging, taking into account the density of anchoring ships and traffic nearby;
.4 Set anchor watch alarm with maps function on radar; the accuracy and reliability depend on the position fixing system; and
.5 Use both guard zone or anchor watch alarm function as an auxiliary means only. Never neglect a continuous visual lookout when using them as sole reliance may lead to danger.

Teamwork is the basis for operating a safe and efficient vessel. The Master will brief the personnel involved with the planned anchoring operation. The engineroom should be updated accordingly. Typical persons attending the briefing include:

- Chief Officer
- Navigating Officer
- Bosun.

Maintaining a safe operation

All checks, inspections and calculations as per Arrival Check List must be completed in sufficient time so as not to interfere with a smooth, planned approach. The company's risk management system must be complied with. Keep the engine room fully advised of the vessel's progress especially when entering: shallow water, high risk areas, restricted or confined waters.

As far as circumstances permit, maintain good communication with the Port Authority and/or Vessel Traffic Services (VTS). Request any information regarding shipping movements which could affect the safe progress of the vessel to the anchor position. The vessel will now proceed to the designated anchor position and anchor as per planned method.

The Chief Officer shall confirm that there is no craft or any obstacle under the bow and inform to the Bridge.

The Master shall ensure that the vessels GPS speed at the time of anchoring is near-zero or indicates a slight sternway.

The speed should be verified by visual transits and/or Radar ranges of Landmarks, if available or other fix conspicuous targets.

Where means of communication between Bridge and the Anchoring party is by Portable radio, the identification of the ship should be clear to avoid misinterpretation of instructions from other user of such equipment in the vicinity**.**

.5 Execute a berthing and unberthing plan to ensure safety of navigation by managing bridge resources effectively by supervising the watchkeeping officer´s radar operation, by evaluating radar information prudently , and by utilizing radar resources properly and effectively

Berthing of ships is a key competence requirement for personnel at the management level, especially masters. During berthing, radar can provide effective support for decision-making with quantitative measurement data.
Management level officers have to note the following radar skills when handling the berthing operations of ships:
.1 Switch range scale in time according to scenarios and handling purpose;
.2 Use VRM to check the distance from the ships or fore and aft obstructions when entering the berthing area. However, the on-scene feedback from fore and aft are always preferable;
.3 Use VRM to monitor the distance between own ship and berth line. In addition, such a practice can be adopted to determine the time of dropping anchor and holding on chain to monitor the ship by the outside anchor if necessary;

.4 Use either EBL or PI line to monitor the angle of berthing by choosing appropriate radar reference target;
.5 Explain and analyze the distribution of blind and shadow areas, which possibly results in no return of berth line on radar screen; and
.6 Explain that the measured range, as stated in relevant applicable radar standards, is the distance between the scanner and object other than the horizontal distance. This difference shall not be neglected when the ship is very close to the berth line at later stage of berthing handling.

The necessity of co-operation and a close working relationship between the master and pilot during berthing and unberthing operations is extremely important to the safety of the ship. In particular, both the pilot and the master should discuss and agree which one of them will be responsible for operating key equipment and controls (such as main engine, helm and thrusters).

The pilot should:

• Co-ordinate the efforts of all parties engaged in the berthing or unberthing operation (for example, tug crews, linesmen, ship's crew). His intentions and actions should be explained immediately to the bridge management team, in the previously agreed appropriate language

In supporting the pilot, the master and bridge personnel should:

• Ensure that the pilot's directions are conveyed to the ship's crew and are correctly implemented • ensure that the ship's crew provide the bridge management team with relevant feedback information

• Advise the pilot once his directions have been complied with, where an omission has occurred or if a potential problem exists

The master and bridge personnel should:
• Within the bridge management team, interact with the pilot providing confirmation of his directions and feed back when they have been complied with
• Monitor at all times the ship's speed and position as well as dynamic factors affecting the ship (for example, weather conditions, manoeuvring responses and density of traffic)
• Confirm on the chart at appropriate intervals the ship's position and the positions of navigational aids, alerting the pilot to any perceived inconsistencies

3. USE OF RADAR IN COLLISION AVOIDANCE

Use of radar in collision avoidance is explicitly stipulated in the COLREG. The radar system is one of the most important instruments for position fixing and safe

navigation, as well as an effective means for proper look-out and ship collision avoidance.
Its important to develop a deep understanding of the significance of positive, early and appropriate actions, and of the relationship among the radar system and proper look-out, safe speed, risk of collision and actions to avoid collision. Master and chief mate should acquire the ability to supervise the officers in charge of a navigational watch to make decisions and take proper actions to avoid collision by the correct use of the radar system information.
Radar, of course, can be used at night or even during the day in clear weather to quickly determine if an approaching vessel (a contact on the screen) has a zero bearing rate; a zero bearing rate means the contact has not changed bearing and you are on a collision course! The contact could be head to head, crossing or overtaking. Using radar, you can determine—early in the encounter—if the approaching vessel is going to be a problem. This determination can usually be made within a few minutes of the contact's first appearance on the screen. There is no need to frantically maneuver your vessel—at the last minute—while an approaching boat gets closer and closer; something, I'm sure, we‘ve all done. There is some urgency in making this determination, however, as radar is line-of-sight and will not paint (identify) a contact beyond the horizon, usually 5- to 10-miles away, depending on your radar antenna height and the size of the approaching vessel.
Many different sensors and systems, from sonar to machine vision, have been installed on ground vehicles and automobiles. This paper describes the use of radar to improve driving safety and convenience. Radars are valuable sensors for all weather operation and experiments with automotive radar sensors have been conducted for over 40 years. This paper shows the advantages and disadvantages of applying microwave and millimeter wave radar to obstacle detection and collision avoidance in a roadway environment. The performance differences between avoidance and warning sensors are discussed and a problem set is devised for a typical forward-looking collision warning application. Various radar systems have been applied to this problem that include pulse and continuous wave transceivers. These system types are evaluated as to their suitability as a collision warning sensor. The various possible solutions are reduced to a small number of candidate radar types, and one such radar was chosen for full scale development. A low cost frequency modulated/continuous wave radar system was developed for automotive collision warning. The radar is attached to the sun visor inside the vehicle, and has been in operation for over four years. The radar monitors the range and range-rate of other vehicles and obstacles, and warns the driver when it perceives that a dangerous situation is developing. A system description and measured data is presented that shows how the 24.075 to 24.175 GHz band can be used for an adequate early warning system.

Avoiding a collision or a close quarter situation with other vessel or any other hazards to navigation is the most important activity conducted at sea. Upon the watchkeeper’s diligence rests the safety and security of the ship, her entire crew, the cargo and the environment. It is a demanding activity, requires support, encouragement, motivation, self-discipline and a high standard of professionalism.

The Master and all deck officers must be fully conversant with the latest edition and amendments of the International Regulations for Preventing Collisions at Sea. The O.O.W. is to take frequent and accurate compass bearings of approaching ships as a means of early detection of risk of collision. Such risk may sometimes exist when an appreciable bearing change is evident particularly when approaching a large vessel or a tow or when approaching a ship at close range. He is to take early and positive action in accordance with the applicable Collision Regulations and then confirm that such action is having the desired effect.

Full use is to be made of radar and ARPA in assessing if risk of collision exists. O.O.W. must not become complacent and rely solely on information from ARPAs. On ocean passages there should be no need for vessels to pass at close quarters and early and prompt action must always be taken. For vessels using ECDIS, the OOW must be aware that vessels not acquired and tracked by ARPA will not appear on the ARPA overlay on the ECDIS display. It is for this reason that ECDIS alone should not be used a collision avoidance tool.

Every vessel is required to proceed at a safe speed at all times in any condition of visibility so that she can take proper and effective action to avoid collision and be stopped within an appropriate distance. When determining a safe speed, rule 6 of the Collision Regulations must be referred to. Key factors to take into account are visibility, traffic density and vessel manoeuvrability.

The state of visibility. Despite the use of radar a visual lookout is always required by the Collision Regulations. If the visibility is significantly reduced the ability of the lookout is hampered. While all ships carry radar, Rule 6 makes it clear that radar has many limitations and constraints. Accordingly a great deal of reliance must therefore still be placed on the lookout.

Traffic density.In coastal waters it can be expected that the traffic density will increase, whether it be other commercial traffic, fishing boats, yachts or other craft. The ability to manoeuvre and take proper and effective action can be restricted in such cases. If the vessel is going too fast then an alteration of course to avoid one close quarter situation may result in another close quarter situation or even a collision. Masters and OOWs are therefore to pay attention to actual density and anticipated density when taking into account a safe speed.

3.1 USE OF RADAR ACQUIRING INFORMATION FOR COLLISION AVOIDANCE

The effective integration and utilization of multiple radar resources, especially comprehensive information integration and analysis, in order to avoid the limitations of sole reliance on radar information. Master and chief mates should be capable of making good judgment and supervising officers in charge of a navigational watch to avoid collision by use of radar.

It would be advisable to review the functions of the radar system in collision avoidance, and these include:
(1) detecting other vessels in time and obtaining early warning of the risk of collision;
(2) obtaining accurate movement elements and collision avoidance information through systematic observation or radar plotting, radar target tracking (ARPA) or AIS reported information and the association of radar tracking targets and AIS reported targets, assessing the situations and risk of collision, and taking proper actions to avoid collision;
(3) determining the actions of the other vessel and checking the effectiveness of the actions taken by both vessels through systematic and continuous observation; and
(4) determining the correct timing for resuming the course (speed) of the own ship by radar plotting, radar target tracking (ARPA) and the association of radar tracking targets and AIS reported targets, ensuring passing at a safe distance.

Master and chief mates have to develop a correct understanding of the error sources and limitations of the information obtained by radar plotting, ARPA or TT/AIS reported information and their association; and to identify the errors of radar plotting, ARPA or TT/AIS reported information and their association for quality navigational information.

Explore the characteristics and limitations of radar plotting and ARPA or TT/AIS by means of discussions and comparisons, emphasizing the importance of thoroughly understanding the basic concepts of radar plotting and the fundamental skills of radar plotting. Master and Chief mates should understand that radar plotting is important even when modern radars with ARPA or TT/AIS functions are used.

Assumptions on risk of collision should not be made based on scanty radar information. Scanty radar information includes the information obtained by improper use of radar equipment, especially those obtained without systematic radar observation or those without consideration of error correction.

.1 analyze the factors affecting the accuracy of manual plotting and evaluate the reliability of plotting information.
AIS Limitations and Guidance

Updated guidance on the use of AIS was promulgated by the IMO in Resolution A.1106 (29). One of the main issues when considering AIS as a source of information is that it merely displays the information supplied by the target vessel. These inputs are susceptible to all the errors possible in computer systems, but could be boiled down to the basic, "Junk in, junk out." In other words if any of the inputs are incorrect or corrupted, then that's what you are getting.
Compare this to the information from an ARPA or your eyes that is independently generated. While those systems are liable to their own perceptions and issues, they are wholly self-supported.

USE OF AIS IN COLLISION AVOIDANCE SITUATIONS
40 The potential of AIS as an assistance for anti-collision device is recognized and AIS may be recommended as such a device in due time.
41 Nevertheless, AIS information may merely be used to assist in collision avoidance decision-making. When using the AIS in the ship-to-ship mode for anti-collision purposes, the following cautionary points should be borne in mind:
.1 AIS is an additional source of navigational information. It does not replace, but supports, navigational systems such as radar target-tracking and VTS; and
.2 the use of AIS does not negate the responsibility of the OOW to comply at all times with the Collision Regulations, particularly rule 7 when determining whether risk of collisions exists.
IMO Res. A.1106 (29)
Possibly the most critical piece of information for the watch on Rickmers Dubai and many other deck watch officers out there is 41.1 above. This guidance from the IMO specifically states that AIS does not replace, but simply supports the information acquired from the radar/ARPA. Unfortunately, it is being observed more and more frequently that AIS is being used as the primary and, sometimes, the only source of information for collision avoidance.

Data Segregation
Why would we want to segregate data? Heck, what does that even mean? When we start using information from multiple sensors (i.e. AIS and ARPA), understanding the limitations of the different sensors as well as the sources of information becomes important. Therefore, the segregating (to separate or set apart from others or from the main body or group - dictionary.com) of data becomes critical.
Again, why? Take for example the ability to place AIS data on your ARPA display - when you do so and you select a particular contact to view it's information, from where does that information come? You might be surprised to learn that even if the

contact has been acquired on your ARPA system, the information displayed may be from the AIS.
This may (or may not be) indicated by an additional symbol or icon on the data page. And the information displayed may (or may not be) significantly different than reality - remember, AIS has many limitations; as does ARPA.
How do we segregate this data? Well, one option might be to NOT overlay the AIS data on the ARPA on a continuous basis. Turning this data on or off to check the ARPA information might be preferable. Another option might be to keep the radar (ARPA) data on the radar and the AIS data on the ECDIS. While this requires visually correlating the data between both units, it does create a situation where "never the tween shall meet" for this critical information.

Evaluation of the credibility of manual plotting information

Manual radar plotting is significant for officers in charge of a navigational watch even with the availability of automatic target tracking function on the radar system. Be reminded that, as officers at the management level, they have the responsibility to advise the OOW against giving up manual radar plotting, and to supervise them when they practice at regular intervals gain and improved understanding of the basic theory and skills of radar plotting.
Importance of reference to obtaining the motion elements of target ships by radar plotting. Have to pay attention of the factors affecting radar plotting accuracy for trainees to gain the ability to analyze error sources of radar plotting in specific situations.

Training in manual radar plotting contributes to enhancing trainees' situational awareness, predicting the movement trend of target ships after the own ship takes action to avoid collision, and coordinating with other ships. As a result, the effectiveness of collision avoidance can be improved.
Deduce the errors of radar target tracking information, AIS reporting information and their associated information; analyze the limitations of processing delay of automatic target tracking system; and evaluate the reliability of information.
Evaluation of the credibility of target tracking (TT) and AIS reporting information

The necessity and importance of the comprehensive application of target tracking (TT) information and AIS reported information in collision avoidance.
Complete familiarization with this section would be helpful for management officer to fully understand and assess the accuracy and reliability of target tracking (TT) information and AIS reported information, to understand their error sources and limitations, to supervise officers in charge of a navigational watch to properly deal with the relationship between target tracking (TT) information and AIS reported

information, and make decisions on collision avoidance appropriate to the prevailing circumstances and conditions.
The use of TT/ARPA as an aid to officers in charge of a navigational watch to avoid collision and reduce their workload to some extent, does not exempt or relieve them of the duty to maintain a proper lookout by other available means.
(1) Errors and limitations of target tracking information
ARPA or target tracking, the primary approach to ship collision avoidance at sea, facilitates acquiring the key information for collision avoidance. Compared with manual radar plotting, this method handles more targets in a shorter time, and manages more continuous tracking with higher data accuracy. All officers are advised to revisit ARPA or TT/AIS reporting functions in their installed equiptment onboard .
Officers have to analysis of the sources of error in radar target tracking information and problems or errors such as mis-acquisition, mis-tracking, target loss, target swop, etc., and elaborate the limitations of the "processing delay" in automatic target tracking systems. Automatic target tracking equipment performance, human factors like improper operation and setting of the equipment, and the objective factors such as the working environment of the radar, target blocking, target manoeuvring, should be highlighted as the causes of the above-mentioned problems or errors.
Specifically, lack of experience, careless observation and rash reaction to the situations are important factors for errors of radar information, and for misunderstanding radar target tracking information. Therefore, officers at the management level should remind the bridge team to pay attention to the above problems and to take precautions against over-reliance on target tracking information.
(2) Errors and limitations of AIS reported information
AIS provides key information for radar target identification, as well as key dynamic information regarding navigation dynamic data and collision avoidance data. Instructors are advised to inform trainees to review the related knowledge of AIS reported target in model courses 1.07 and 1.34. During the course, analyzes of factors causing errors of AIS reported information, and elaborate the limitations of the application of AIS reported target on radar.
AIS has its own limitations and can be used only as an aid to avoid collision. AIS only provides supplementary information and should never be a substitute for radar tracked target information in collision avoidance. The association of AIS reported targets and radar tracked targets is the key to collision avoidance handling.
(3) The association of radar tracked targets and AIS reported targets
For radar systems that meet the Revised Recommendation on Performance Standards for Radar Equipment set out in resolution MSC. 192(79), the association of radar tracked targets and AIS reported targets is conducive to the determination of situations and risk of collision. Trainees should be reminded to revisit model course 1. 07 to review the fundamentals of the association of radar tracked targets and AIS reported targets.

During the training, Instructors should supervise trainees to set proper criteria for association based on such factors as traffic density, equipment accuracy and weather conditions, with a clear understanding of the risks of inadequate criteria setting for the association of radar tracked target and AIS reported target

3.2 USE OF RADAR IN COLLISION AVOIDANCE ACTIONS

Management officers (Master /Chief mates) have to gain knowledge to obtain reliable collision avoidance information from radar target tracking, AIS reported targets, the association of radar tracked with AIS reported targets, manual radar plotting and equivalent systematic observation. In response to the prevailing circumstances and conditions, and be able to make effective use of bridge resources to properly identify situations, determine if the risk of collision exists, make proper decisions and take corresponding actions for collision avoidance, check the effectiveness of these actions, and determine the timing of restoring the original course or/and speed of vessels.

Its important to Review the basic theories and the use of radar and the COLREG, and focus on the radar-related rules, to effectively use and manage bridge resources, and supervise the bridge team when using radar to assist in collision avoidance, and take proper and effective actions in accordance with COLREG.

The association of radar tracked with AIS reported targets, manual radar plotting and equivalent systematic observation; effectively manage bridge resources; differentiate and evaluate the radar information; and properly appraise situations according to the prevailing circumstances and conditions.

Proper identification of situations is the key to proper decision-making for collision avoidance, and for instructing the bridge team to take effective collision prevention measures. Based on a comprehensive review of radar theories and the COLREG relating to the situations, and taking into account of master standing orders, management officers should gain a thorough understanding of all the means of identifying ship situations based on the radar information, including but not limited to the following:

(1) obtaining the range, bearing, course and speed of target ships by radar target tracking;

(2) obtaining type of ship, and position, heading, course, speed, navigation status and destination of target ships by AIS reported targets;

(3) obtaining optimal collision avoidance information of target ships by the association of radar tracked with AIS reported targets; and

(4) obtaining the range and bearing of target ships through systematic and continuous observation of detected objects; then obtaining the course and speed of target ships by plotting.

Of the above, radar target tracking is the primary approach to obtaining collision avoidance information, which detects targets independently, tracks target data automatically, and processes multi-targets at the same time with reliable data. AIS is an interactive system of voyage data, which relies on GNSS and other ship's equipment to obtain more comprehensive information including ship identification information. With the criteria fulfilled, the association of radar tracked with AIS reported targets reduces redundant information, acquires optimal information and possesses obvious advantages for collision avoidance. Manual radar plotting is a basic skill for officers in charge of a navigational watch, which takes a longer time and handles less targets with lower data accuracy.

Officers should take account of the errors and limitations of radar equipment appropriate to the prevailing circumstances and conditions, and choose proper means to measure the range, bearing, course and speed of target ships, so as to properly identify situations in accordance with COLREG. Situations are subject to change, and officers should take all available means, such as uninterrupted look-out, exchanges of information with target ships, communication and cooperation among the bridge teams, etc., to identify and handle information for continuous and proper identification of situations.

acquire reliable collision avoidance information through radar target tracking, AIS target reporting, the association of radar tracked with AIS reported targets, manual radar plotting and equivalent systematic observation; effectively manage bridge resources; differentiate and evaluate the radar information; and properly determine if risk of collision exists according to the prevailing circumstances and conditions.

.2 Identifying and evaluating radar information to determine risk of collision

It is the premise for collision decision-making to determine risks of collision and radar is the effective means. Based on a comprehensive review of model course 1.07 and Rule 7 of COLREG on Risk of collision, and referring to master standing ordes, trainees should properly identify situations, focus on tracking target ships with potential risk of collision, and have a full understanding of the following:

.1 CPA and TCPA provide main basis for determining risk of collision.

- When CPA＞CPA LIM, the target is non-dangerous;
- In case CPA≤CPA LIM, TCPA>TCPA LIM, the target poses no immediate danger and officers in charge of a navigational watch should follow the change of TCPA; and
- If CPA≤CPA LIM, TCPA≤TCPA LIM, the target is dangerous and officers in charge of a navigational watch should make corresponding collision avoidance decision.

.2 Means of determining risk of collision by radar information include: target tracking, AIS reported targets, the association of radar tracked with AIS reported targets, manual radar plotting and equivalent systematic observation. Based on these means, trainees can acquire CPA and TCPA of target ships and determine risk of collision. For estimation of CPA and TCPA with big errors by systematic observation equivalent to manual plotting, officers require good skills and wide experience, and officers at the management level should reinforce the guidance to officers of the watch.

Every vessel should use all available means appropriate to the prevailing circumstances and conditions to determine if the risk of collision exists. Emphasize that officers should Identify and evaluate CPA and/or TCPA, taking into account the errors and limitations of the radar equipment, scanty radar information, and the fact that the bridge team may have a different understanding of CPA LIM and TCPA LIM. During classroom will be develop study and discussion of typical cases, to acquire better ability to determine the risk of collision when using radar.

.3 interpret conduct of vessels in sight of one another and in restricted visibility and use radar to obtain reliable collision avoidance information; differentiate and evaluate the radar information; effectively manage the bridge resources; and make proper decisions and take effective actions for collision avoidance according to the prevailing circumstances and conditions.

Based on a comprehensive review of model course 1.07 regarding radar information, and the COLREG regarding actions to avoid collision, and with reference to model course 1.22, trainees should gain a full understanding of how to use the radar information and instruct the bridge team to make proper decisions and take proper actions to avoid collision in accordance with COLREG, Rules 11 to 19 in Part B on Steering & Sailing Rules.

.1 Different decisions towards different situations lead to different collision avoidance actions. Based on proper identification of situations and determination of collision risks mentioned above, management officers should consider the errors and limitations of the radar equipment, and make proper decisions in accordance with requirements for preventing collision for various situations. In addition, trainees should instruct the bridge team to take proper actions to contain the development of close-quarters situations.

.2 A series of collision avoidance actions may be taken for complex situations. In such cases, officers should make a comprehensive analysis of radar information and relevant collision avoidance measures, and conduct an intensive examination of the accuracy and limitations of the information, for example, different CPA and/or TCPA of multiple target ships encountered means different degrees of risk of collision and urgency. Management officers should prioritize the sequence of collision avoidance actions and choose the key target and analyze the influence of the errors and limitations of the radar system. A full appraisal of the possible changes of complex situations should also be conducted, and the immediate and proper actions should be taken.

.3 Radar information provides major support for decision-making. Generally, when CPA LIM should be larger in restricted visibility, earlier and more substantial action should be taken for collision avoidance than in good visibility. In case of course alteration, manoeuvring diagram of radar for preventing collision should be fully used, with due consideration given to the rules of the COLREG. In particular, personnel at the management level should be able to: give overall consideration to the errors and limitations of the radar equipment; conduct effective and efficient management of the bridge team; make prompt and proper decisions to take collision avoidance actions in adverse weather and complex traffic situations.

Whether ships are in sight of one another, or in restricted visibility, management officers should be able to make proper use of radar information and to make proper decisions and take effective collision avoidance actions. Emphasize that keeping a proper visual lookout is the most basic and important method in the process of collision avoidance. Nevertheless, radar information provides an irreplaceable advantage for collision avoidance. However, in restricted visibility, inadequate and imprecise visual lookout may not give full support to collision avoidance actions and will thus affect the accurate evaluation of the radar information which may lead to inappropriate interpretation of the radar information by the bridge team. It should be noted that complex situations and possible changes at any time, especially small and uncoordinated collision avoidance actions, may endanger the safety of navigation.

Thus, in any situation and condition the key to safe navigation is to strengthen the visual lookout; to make use of the radar equipment; to communicate effectively among the bridge team; to comprehensively analyze the visual and radar information and other information conducive to collision avoidance; to use all available bridge resources, and make proper decisions and take effective collision avoidance actions in accordance with COLREG.

Avoiding a close quarter situation with other vessel or any other hazards to navigation is the most important activity conducted at sea. Upon the watchkeeper’s diligence rests the safety and security of the ship, her entire crew, the cargo and the environment. It is a demanding activity, requires support, encouragement, motivation, self-discipline and a high standard of professionalism.

The Master and all deck officers must be fully conversant with the latest edition and amendments of the International Regulations for Preventing Collisions at Sea. The O.O.W. is to take frequent and accurate compass bearings of approaching ships as a means of early detection of risk of collision. Such risk may sometimes exist when an appreciable bearing change is evident particularly when approaching a large vessel or a tow or when approaching a ship at close range. He is to take early and positive action in accordance with the applicable Collision Regulations and then confirm that such action is having the desired effect.
Full use is to be made of radar and ARPA in assessing if risk of collision exists. O.O.W. must not become complacent and rely solely on information from ARPAs. On ocean passages there should be no need for vessels to pass at close quarters and early and prompt action must always be taken. For vessels using ECDIS, the OOW must be aware that vessels not acquired and tracked by ARPA will not appear on the ARPA overlay on the ECDIS display. It is for this reason that ECDIS alone should not be used a collision avoidance tool.
Apply COLREGS in open waters in restricted visibility

RULE 19 - CONDUCT OF VESSELS IN RESTRICTED VISIBILITY

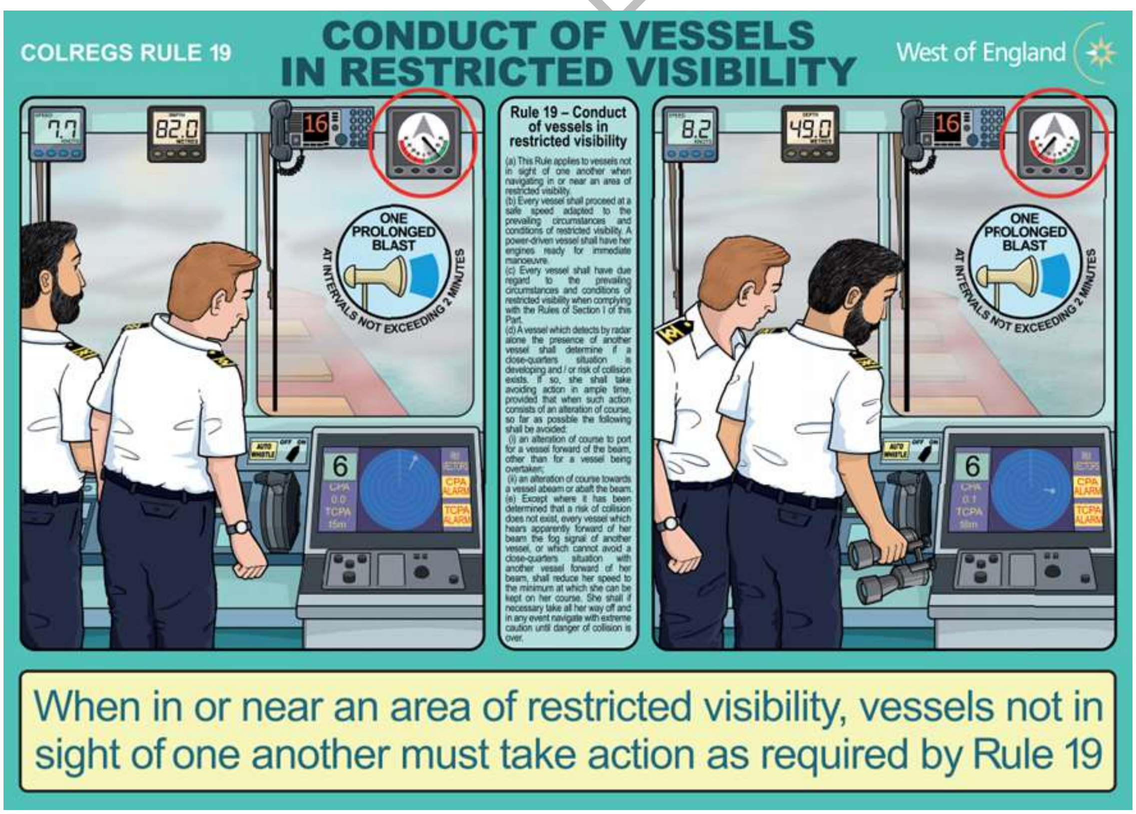
This Rule applies to vessels not in sight of one another when navigating in or near an area of restricted visibility.

Every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. A power-driven vessel shall have her engines ready for immediate maneuver.

Every vessel shall have due regard to the prevailing circumstances and conditions of restricted visibility when complying with the Rules of Section I of this Part.

A vessel which detects by radar alone the presence of another vessel shall determine if a close-quarters situation is developing and/or risk of collision exists. If so, she shall take avoiding action in ample time, provided that when such action consists of an alteration of course, so far as possible the following shall be avoided:

- An alteration of course to port for a vessel forward of the beam, other than for a vessel being overtaken;
- An alteration of course toward a vessel abeam or abaft the beam.



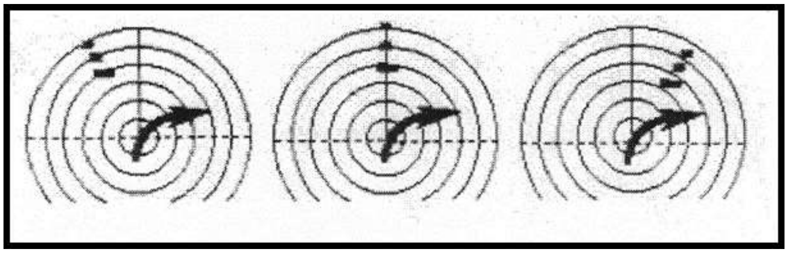
A vessel which detects by radar alone the presence of another vessel. The rule applies when any target is first detected anywhere on the radar screen, forward, aft, port or starboard.
It also states that you do not see the target visually, but this is also implied in that this rule is in Section II, which applies to vessels in or near conditions of restricted visibility. Remember this rule applies when you are near fog as well as in it. You could have clear skies and detect a vessel in fog bank miles from you.

Whether or not you have heard it is another matter (it says radar "alone") if you have heard a vessel you can't see, there are specific rules (Rule 19 e) for that situation. Furthermore, you cannot always be certain that the vessel you detect on radar is the one you hear, especially if there is more than one target present. Shall determine if a close-quarters situation is developing and/or risk of collision exists.

"Close quarters" is discussed in Lesson 5. It is that safety zone you need to maintain about you so that you can maneuver on your own to avoid a collision if you have to, regardless of what the other vessel might do. It is some radius the size of which depends on the circumstances. In the fog with a fast moving deep sea vessel approaching, it is certainly measured in miles, not fractions of a mile.
This can be viewed as a minimum CPA you will accept as safe passing.

Hence our first job is to track the vessel ("systematic observations") to make an evaluation as soon as possible of its relative plot to determine how this is developing with regards to actual collision risk with everyone operating normally plus the extra safety standards of preventing close quarters situation.
If you are a sailing vessel, for example, under difficult conditions of big waves and strong winds, then you must figure into this reckoning what type of wind shifts might be expected and how you might have to respond with course changes. A power-driven vessel might not understand these constraints. Radio contact is always valuable in these conditions. If so, she shall take avoiding action in ample time.
Note the crucial distinction in the wording here compared to interactions in clear weather. We are not avoiding a collision when risk of collision exists, as in clear weather, but rather are avoiding the "development" of close quarters or collision risk itself. It is a clear call for earlier, more conservative actions.
However, it is also important to remember Rule 7c which applies to all evaluations of risk of collision: assumptions should not be made on the basis of scanty radar information. In other words, we need to make whatever systematic observations are required so that we can indeed determine if risk is developing. To just see a target and maneuver is both wrong and dangerous.

Provided that when such action consists of an alteration of course. The rule then gives explicit instructions that cover all cases.
So far as possible the following shall be avoided:
An alteration of course to port for a vessel forward of the beam, other than for a vessel being overtaken.



The exception is when the approaching target is one we are overtaking.
Remember the definition of overtaking our course within 62.5° of theirs or their aspect greater than 112.5°. To know this, however, we must evaluate the RMD. We have no other way of knowing. The vessel being overtaken can approach us on the radar screen from anywhere forward of the beam. Furthermore, the first part of this rule has already told us that we must make this evaluation as our first obligation.
When the target is moving down screen from ahead this is simple to figure. If their SRM is less than our speed, we are overtaking them. On all other diagonal approaches, we must evaluate the RMD.

When interacting with a crossing or meeting vessel in the fog, neither vessel has "right of way," in distinct contrast to vessels approaching in clear weather. Both are instructed by this rule to move as prescribed above. When overtaking, however, we do have other rules that apply in any condition of visibility. Namely Rule 4 to stay clear when overtaking and rule 6 to do so early and prominently.

When overtaking, then, it is our obligation to make an early and prominent maneuver to stay well clear. The target in turn on his radar will see us approaching up screen from aft of his beam. His job will then be to decide if close quarters is developing and if so to turn away from us.
Note the big distinction here between navigation in sight and not in sight. When we are being overtaken in clear weather we are instructed to hold course and speed.

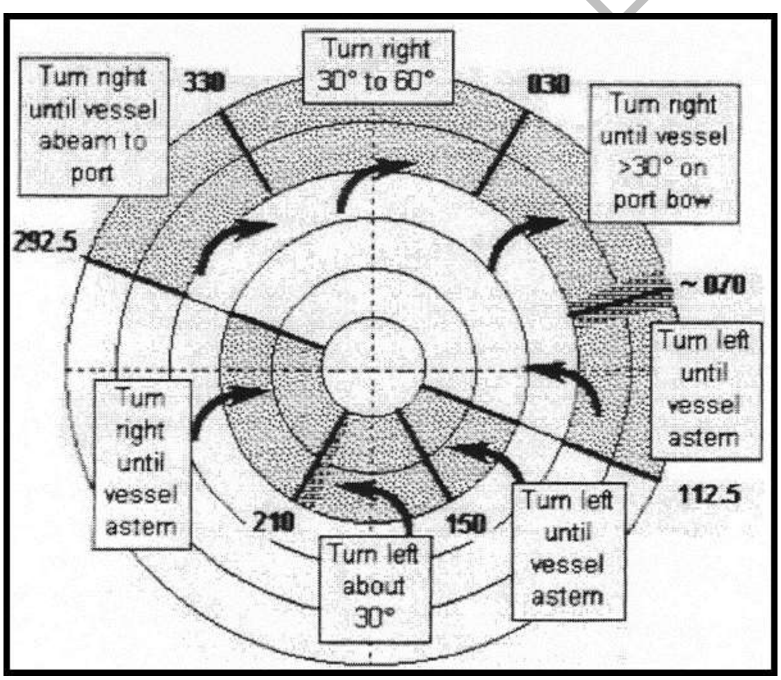
But when we see someone overtaking us by radar alone, and they are headed toward close quarters, then we must move away from them.
So far as possible the following shall be avoided:

- An alteration of course toward a vessel abeam or abaft the beam.

- This rule tells us that we should turn away from any target approaching from aft the beam. If it approaches from the port quarter, we turn right, and if from the starboard quarter, we turn left.

Note that this latter circumstance, a target approaching from the starboard quarter is the only circumstance that calls for a turn to the left. All other cases call for a turn to the right.

A more specific compilation of maneuvering guidelines is presented in the figure, which was adapted from the work of Cockcroft and Lameijer.
This Diagram is a summary of typical course alterations in response to the detection of a radar target at various bearings. It is presumed that the target is not in sight and that maneuvering is according to Rule 19d.
For targets appearing at forward bearings (from about 292 R to 112 R) the responses are referred to as "Normal turns, made preferably at target ranges of 4 to 6 miles." This is indicated schematically by the shaded regions spanning these ranges.
Turns in response to targets appearing aft of that line are called "Escape action, taken preferably at ranges less than 3 miles." Again, shown shaded a



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COURSE ALTERATION DIAGRAM

Needless to say, these are only guide lines to typical turns that meet the intentions of the Rules away from special circumstances that might call for special maneuvers. The numerical values quoted here are not specified in any rule.

A notable feature included in this diagram from Cockcroft and Lameijer is the extension of the region of "starboard beam" to some two points forward of 090 R and an extension of the port turn domain some 30° into the region of the port quarter. A cursory literal reading of the rule would have these boundaries be at 090 R and 180 R, rather than the approximate 070 and 210 given in the diagram. The Radar Trainer provides an ideal way to demonstate the logic and value of the Cockcroft-Lameijer interpretation.

First note that the wording of the rule does indeed offer some flexibility on this interpretation.

A careful study of this diagram answers many of the difficult questions a navigator is confronted with when interacting with traffic in the fog and in clear weather. Needless to say, these are guidelines only. A frequent example of "special circumstances" is the presence of more than 2 vessels in the interaction.

- Except where it has been determined that a risk of collision does not exist, every vessel which hears apparently forward of her beam the fog signal of another vessel, or which cannot avoid a close-quarters situation with another vessel forward of her beam, shall reduce her speed to the minimum at which she can be kept on her course. She shall if necessary take all her way off and in any event navigate with extreme caution until danger of collision is over.

.4 acquire reliable collision avoidance information through radar target tracking, AIS target reporting, the association of radar tracked with AIS reported targets, manual radar plotting and equivalent systematic observation; effectively manage bridge resources; differentiate and evaluate the radar information; and appraise the effectiveness of collision avoidance actions according to the prevailing circumstances and conditions.

Checking the effectiveness of collision avoidance actions

Based on a comprehensive review of model course 1.07 relating to radar information and actions to avoid collision, and Rule 8 of COLREG, management officers should have a thorough understanding of the following:

.1 Criteria for checking the effectiveness of collision avoidance actions include: actions in accordance with COLREG; being visible to the other vessel, visually or by the radar; passing at a safe distance. CPA is the main basis for determining safe distance. When CPA＞CPA LIM, actions are effective; but if CPA≤CPA LIM, actions are ineffective.Management officers should understand well that the accuracy of radar information affects the determination of the effectiveness of collision avoidance actions.

.2 Information obtained from radar target tracking, AIS reported targets, the association of radar tracked with AIS reported targets, and manual radar plotting and equivalent systematic observation can be used to check the effectiveness of collision avoidance actions. Application and features of these methods are stated in section 1 and 2 of this sub-topic. Through these methods officers can acquire CPA of target ships after collision avoidance actions, check if actions achieve desired results, and confirm that both ships are passing at a safe distance.

Emphasize that the action taken for collision avoidance may not be effective, or may not achieve the expected safe distance, or the effectiveness may even be compromised, or offset by uncoordinated actions by target vessels. Therefore, watchkeeping officers on every vessel should carefully check the effectiveness of collision avoidance actions. Management officers should fully consider the errors of the radar information and evaluate their effects to ensure the radar information is effective, and they should manage and make proper use of bridge resources, and check the effectiveness of collision avoidance actions.

It is recommended that target vessels with uncoordinated actions should be added in the practical training exercises. For example, when a target ship is approaching from the port bow, deceleration of own ship would conflict with starboard alteration or deceleration of the target ship, or owing to limited visual lookout in restricted visibility it is necessary to switch on more than one radar to make full use of the radar resources and check the effectiveness of collision avoidance actions by acquiring different radar information continuously.

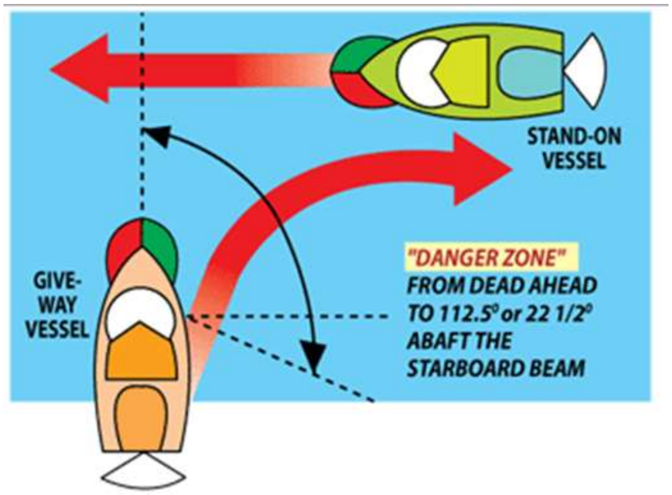
RULE 8 - ACTION TO AVOID COLLISION

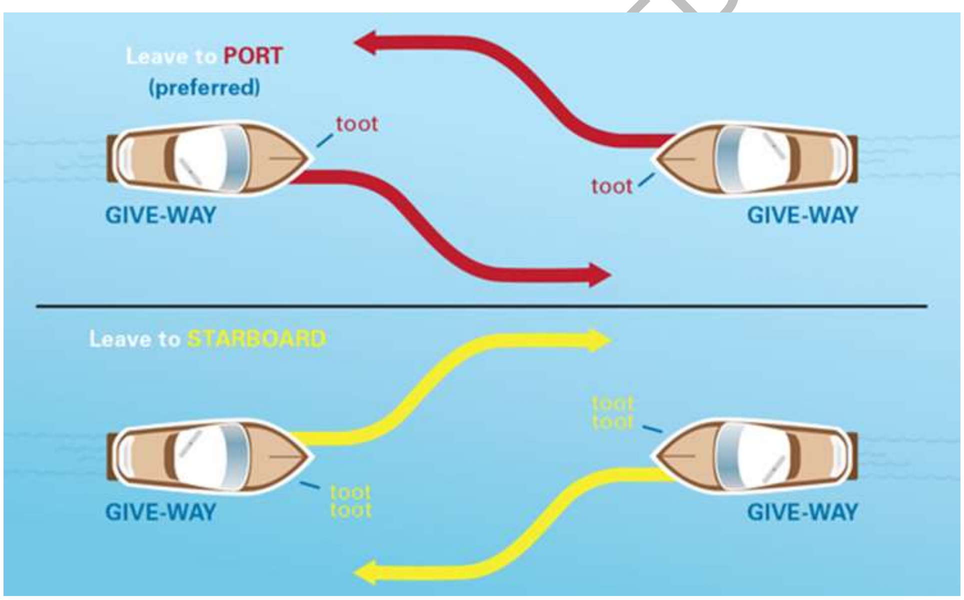
- ✓ Any action taken to avoid collision shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship.
- ✓ Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided.

EXPLANATION

- ✓ Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided.

Note that this rule applies in all conditions of visibility and even to those vessels which do not carry radar. When you maneuver, it should be visible to the other vessel observing "by radar." This calls for large turns, on the order of 60° or more. The course alteration diagram provides a set of guidelines that cover most circumstances in normal conditions.

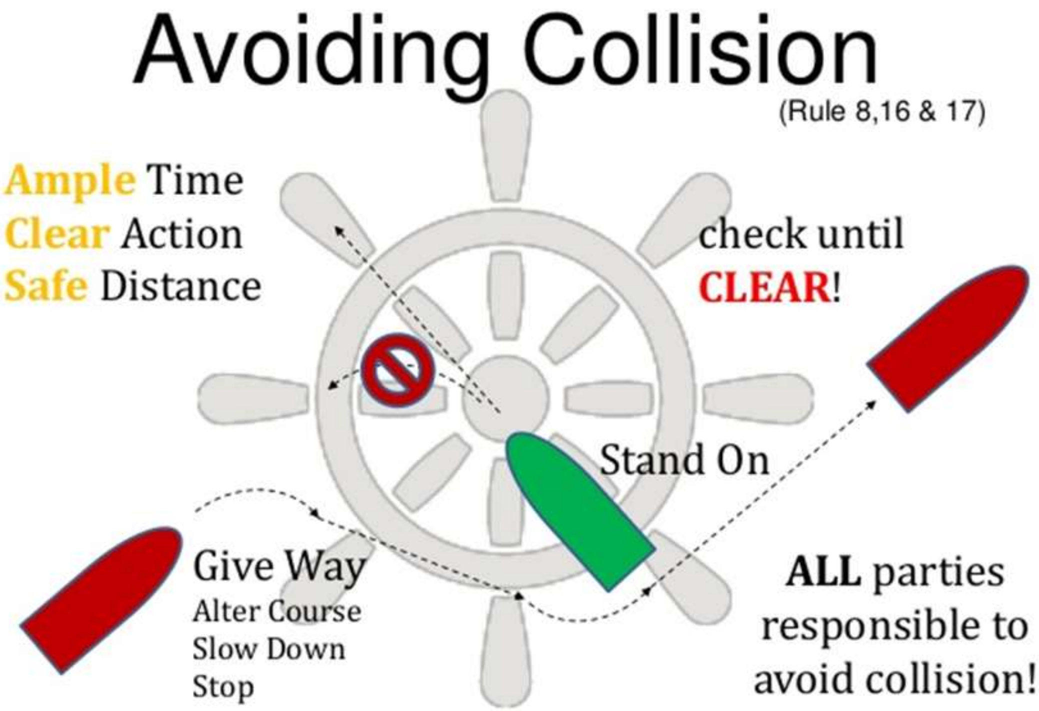




Remember too, we can always stop. A collision course situation which develops when we are moving and a target is approaching diagonally will appear as a relative motion plot aimed straight towards us on the radar screen. If we stop, the target's relative motion trail will curve up screen and the collision threat will be alleviated.

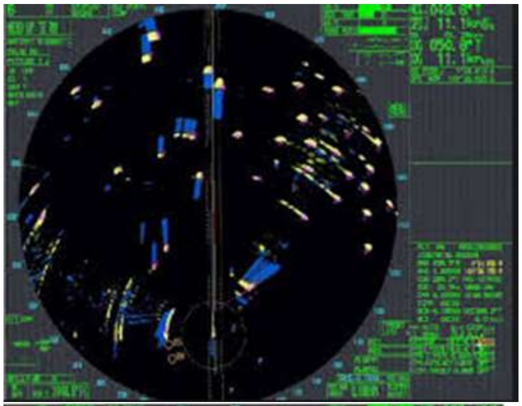
The Radar Trainer provides a very convenient means of investigating what degree of turning can be seen on radar and the opportunity to practice with the simple expedient of stopping.

- ✓ If there is sufficient sea room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.
- ✓ Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear.
- ✓ If necessary to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.
  - A vessel which, by any of these rules, is required not to impede the passage or safe passage of another vessel shall, when required by the circumstances of the case, take early action to allow sufficient sea room for the safe passage of the other vessel.
  - A vessel required not to impede the passage or safe passage of another vessel is not relieved of this obligation if approaching the other vessel so as to involve risk of collision and shall, when taking action, have full regard to the action which may be required by the rules of this part.
  - A vessel, the passage of which is not to be impeded remains fully obliged to comply with the rules of this part when the two vessels are approaching one another so as to involve risk of collision.



3.2 Plan and control safe navigation and collision avoidance in confined and congested water

High density traffic waters (referred to as "Congested waters") means:
An area of water where due to presence of many vessels in the vicinity, a repeated risk of collision exists and it may be difficult for own vessel to maintain her course.
An area of water where the situation repeatedly arises in which a vessel is likely to collide with another vessel and an action to avoid a collision is limited by the existence of a third vessel or fixed structure, or where such situation is expected to arise.



i) International Regulations for Preventing Collisions at Sea, 1972 mention:
Rule 6: Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and condition.
In determining a safe speed the following factors shall be among those taken into account:
(a) By all vessels:
(i) the state of visibility;
(ii) the traffic density including concentrations of fishing vessels or any other vessels;
(iii) the maneuverability of the vessel with special reference to stopping distance and turning ability in the prevailing conditions;
(iv) at night the presence of background light such as from shore lights or from back scatter of her own lights;
(v) the state of wind, sea and current, and the proximity of navigational hazards;
(vi) the draught in relation to the available depth of water.
(b) Additionally, by vessels with operational radar:
(i) the characteristics, efficiency and limitations of the radar equipment;

(ii) any constraints imposed by the radar scale in use;
(iii) the effect on radar detection of the sea state, weather and other sources of interference;
(iv) the possibility that small vessels, ice and other floating objects may not be detected by radar at an adequate range;
(v) the number, location and movement of vessels detected by radar;
(vi) the more exact assessment of the visibility that may be possible when radar is used to determine the range of vessels or other objects in the vicinity.
Rule 8 (e): If necessary to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.
ii) Rules for Vessels navigating through the Straits of Malacca and Singapore
Rule (7): VLCCs1 and deep draught vessels navigating in the Straits of Malacca and Singapore shall, as far as it is safe and practicable, proceed at a speed of not more than 12 knots over the ground in the following areas:
(a) At One Fathom Bank traffic separation scheme;
(b) Deep-water routes in the Phillip Channel and in Singapore Strait; and
(c) Westbound lanes between positions 01°12.51’N, 103°52.15’E and 01°11.59’N, 103°50.21’E and between position 01°11.13’N, 103°49.08’E and 01°08.65’N,103°44.30’E.
Rule 8: All vessels navigating in the roueting system of the Straits of Malacca and Singapore shall maintain at all times a safe speed consistent with safe navigation, shall proceed with caution and shall be in a maximum state of manoeuvring readiness.
The OOW must always be aware of the possibility of navigation in congested waters, and if the vessel is expected to navigate such areas, he must take the following action:

- Early evacuation from the congested area, if possible.
- Arrangement of Lookout(s).
- Report to the Master.
- Test of manual steering or changeover to manual steering.
- Contact with Engineers, if necessary
- Reduction to a safe speed, if required.
- Running in Parallel of Power units of Steering gears.

Action of the masters in congested waters
The Master, when the vessel is in congested waters or upon receiving the report from the OOW above, must confirm the situation and increase officers or ratings for lookout as required. He shall take over the command of the vessel.
Acttion of the master and officer of the watch in restricted visibility conditions :

If the vessel encounters congested waters under restricted visibility conditions, the Master and OOW must navigate the vessel carefully according to the provisions of the "Procedures for Navigation in Restricted Visibility Conditions" in addition to those outlined above.

A comprehensive passage plan to be available for the voyage and it cover the full voyage from berth to berth. Notes: The following should be marked on the chart, where it enhances safe navigation:

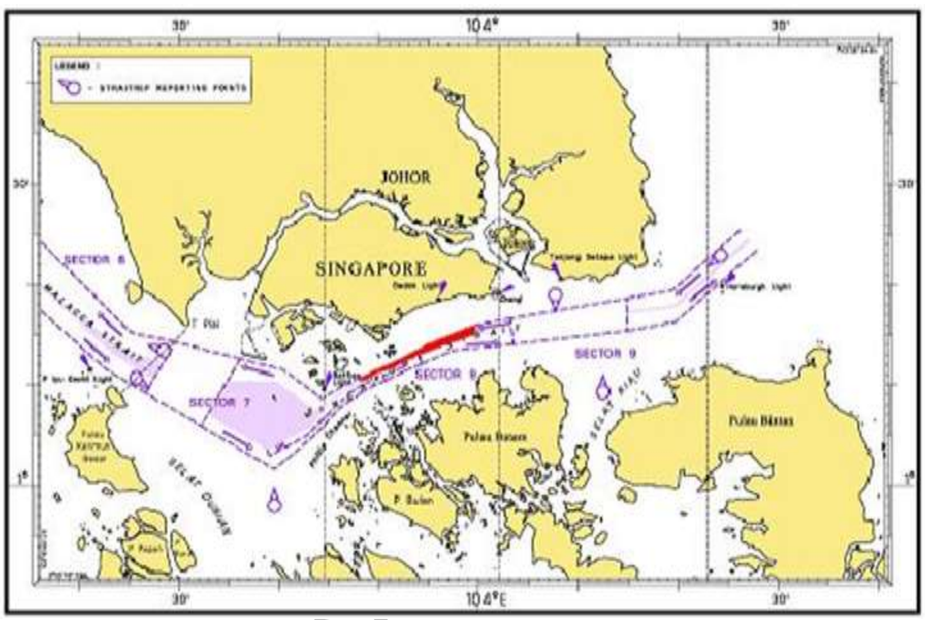
- Parallel indexing (not from floating objects);
- Chart changes;
- Methods and frequency of position fixing;
- Prominent navigation and radar marks;
- No-go areas;
- Landfall targets and lights;
- Clearing lines and bearings;
- Transits, heading marks and leading lines;
- Significant tides or current;
- Safe speed and necessary speed alterations;
- Changes in machinery status;
- Minimum under keel clearance;
- Positions where the echo sounder should be activated;
- Crossing and high density traffic areas;
- Safe distance off;
- Anchor clearance;
- Contingency plans;
- Abort positions;
- VTS and reporting points, etc

3.3 Control navigation and collision avoidance in and near traffic separation schemes

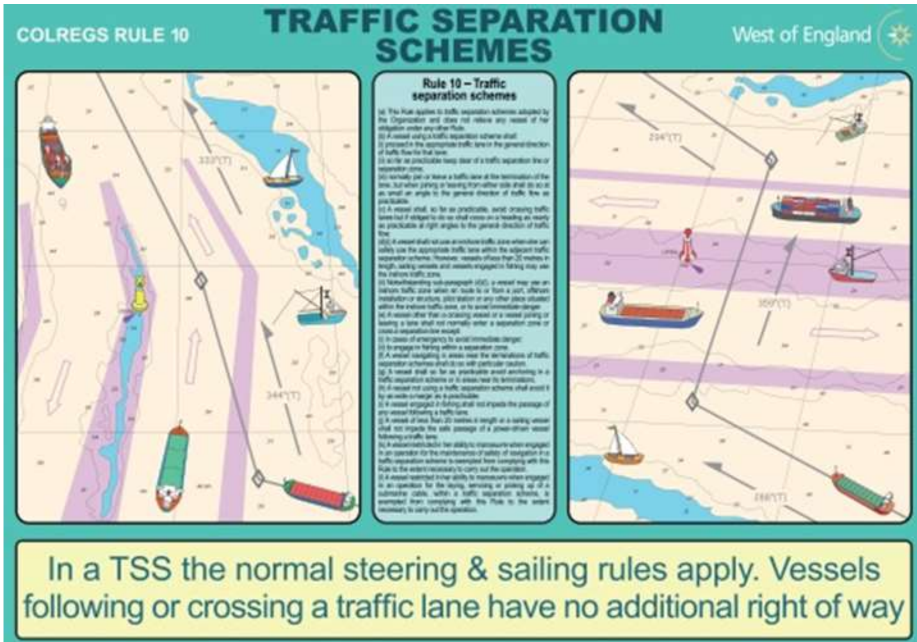
3.3.1 Traffic Separation Schemes (TSS) TSS's are frequently monitored by radar coverage by coastguard personnel, (e.g. Dover Strait, Malaca Strait, etc). With AIS it is easy to identify vessels. Particular emphasis is therefore required regarding compliance with

Rule 10 and in particular when crossing the traffic lanes. The rule requires:

(c) A vessel shall, so far as practicable, avoid crossing traffic lanes but if obliged to do so, shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow.



This is strictly enforced and vessel Masters have been fined in European Courts. It is essential that all Deck officers fully understand the requirements of Rule 10.



All passage plans must clearly show that the intention is to cross the lane at right angles or as close to as is practical. This minimizes the time a crossing vessel is in the lane irrespective of the tidal stream and should lead to a clear encounter situation with vessels passing through the main traffic lanes.

The UK MCA have issued MGN 364 which relates to the Dover Straits, however, the general separation scheme principles in Section 2 (Traffic Separation Schemes – Application of Rule 10) are equally applicable toall schemes and should be fully understood by Officers of the Watch.

.5 acquire reliable collision avoidance information through manual radar plotting and trial manoeuvre; effectively manage the bridge resources; differentiate and evaluate the radar information; and determine the time of restoring the original course or/and speed according to the prevailing circumstances and conditions.

Determining the timing of restoring the original course or/and speed of vessels in sight of one another and in restricted visibility

Based on a comprehensive review of model course 1.07 and COLREG Rule 8, officers should gain an understanding of the following:

.1 "Past and clear" in Rule 8 refers to the situation where two vessels pass at a safe CPA after collision avoidance actions, even after restoring the original course or/and speed. Instructors should emphasize that situations are complex for multiple ships in restricted waters. Personnel at the management level should give full consideration of the complexity and diversity of situations and improve the bridge team's situational awareness so that continuous radar information is obtained and its reliability is evaluated; and

.2 Information obtained from manual radar plotting and trial manoeuvres can be used to determine the timing of restoring the original course or/and speed of vessels. Manual radar plotting takes a longer time, with only a small number of targets plotted and the relatively more errors and limitations. Based on radar target tracking, trial manoeuvre needs a shorter time, with relatively fewer errors and limitations. However, performance and accuracy of trial manoeuvres vary with different radar produced by different manufacturers.

Keeping in mind the limitations, trainees should use a variety of methods and determine the restoring timing comprehensively.

Radar information is relevant for determining the timing of restoring the original course or/and speed of vessels. In order to further improve trainees' ability for managing “pass and clear” by the proper use of radar, it is recommended that Instructors should add multiple ship situations in restricted waters in practical training exercises. This will facilitate the improvement of the awareness of proper use of radar resources, and enhance communication and cooperation in the bridge team, to ensure good understanding and assessment of the prevailing circumstances and conditions, and determination of the timing for restoring the original course or/and speed of vessels for safe navigation.

Practical training 3 - Use of radar in collision avoidance

.1 Training objectives

Practical training is an indispensable part of the course, and aims to help trainees to become familiar with the use of radar in complicated navigational circumstances, especially in limited and dense traffic waters. This should enable trainees to acquire full radar information and comprehensively evaluate its reliability, identify situations, determine risk of collision, make proper decisions, and instruct the bridge team to handle collision avoidance for the safety of navigation.

.2 Training scenarios

It is recommended that the practical training should be conducted using an approved bridge simulator suitable for this course. Instructors should prepare training exercises in advance.

Training scenarios should involve, but not be limited to the following:

.1 Types of ship: To improve the training effectiveness, Instructors should edit the own ships' type, tonnage or draft in advance;

.2 Training waters: They include but are not limited to: pilot station and adjacent waters, channels, anchorages, confined waters, TSS areas, VTS areas;

.3 Target ships: It is recommended that at least 10 different types of target ships be available for crossing, head-on, overtaking etc. In addition, at least 2 target ships are required and a Manoeuvring Diagram is needed; and

.4 The weather and sea state: It is advisable to include good visibility, restricted visibility with due regard to wind, waves, currents and other circumstances.

4. USE OF RADAR IN SEARCH AND RESCUE

Maritime search and rescue operations should be conducted in accordance with requirements of SOLAS Chapter V and the International Aeronautical & Maritime Search and Rescue (IAMSAR) Manual. Instructors should elaborate the objective of SOLAS Chapter V, and setting search area and the requirements for CCS operations. Trainees should understand the importance of establishing contacts with other SAR units (SAR centres, lifeboats, helicopters), and the applicability of COLREG in search and rescue operations.

This topic mainly covers how radar can be used by the personnel at the management level in formulating and implementing SAR plans, and following should be covered: comprehensive use of radar information and related SAR units for identification and confirmation of the search object; timely adjustment of the radar and proper use and evaluation of radar information for proper decision-making while approaching the search object; manoeuvring the ship for successful SAR mission through effective team work.

4.1 Identification and confirmation of distress locating signals

Personnel at the management level should be able to identify and evaluate distress information relating to search and rescue operations. They should also be able to search by radar or other means, the target in distress with locating devices, and be quick to respond and make correct judgments in complex navigation situations so that the target in distress can be located and approached with proper manoeuvring to ensure a successful SAR operation.

A distress signal, also known as a distress call, is an internationally recognized means for obtaining help. Distress signals are communicated by transmitting radio signals, displaying a visually observable item or illumination, or making a sound audible from a distance.

A distress signal indicates that a person or group of people, ship, aircraft, or other vehicle is threatened by serious and/or imminent danger and requires immediate assistance. Use of distress signals in other circumstances may be against local or international law. An urgency signal is available to request assistance in less critical situations.

In order for distress signalling to be the most effective, two parameters must be communicated:

- Alert or notification of a distress in progress
- Position or location (or localization or pinpointing) of the party in distress.

Distress traffic includes all messages relating to immediate assistance required by persons, aircraft, or marine craft in distress, including medical assistance. Distress traffic may also include SAR communications and on-scene communications. Distress calls take absolute priority over all other transmissions; anyone receiving a distress call must **<u>immediately cease any transmissions that may interfere with the call and listen on the frequency used for the call.</u>**

The object of search and rescue (SAR) communications is to make possible the conduct of SAR operations. As per Regulation 7 of Chapter V of SOLAS, arrangements have been established to facilitate distress communication.

Such communications must allow for:

a) Rapid transmission of distress messages from aircraft, ships and small craft, including for medical assistance;

b) b) Rapid communication of distress information to the authorities responsible for organising and effecting rescue;

c) Coordination of the operation of the various SAR units; and

d) Liaison between controlling/coordinating authorities and SAR units.

.1 Identification, evaluation and acknowledgement of radar SART information

(1) Knowledge of radar SART

Management level officers should develop familiarity with radar SART-related knowledge. During the training, a review SART-related knowledge will be done, with emphasis on such features as working band, effective detection range of the signal, radar range of observation, echo characteristic. The influence of frequently used control buttons on the SART observation should be stressed.

SART is the acronym for Search and Rescue Transponder, which is often translated simply as "radar transponder".

The SART, basically, is designed for use in the liferaft, although it could also be used from a ship that is in danger. The advantage of being activated from a liferaft, is because this, liferaft are build of rubber and can not be detected by a radar, which needs a good reflection surface to get a clear "echo" and clearly visible on the screen. The SART will help it to be located.

The SART will enter a "stand-by" mode at moment be activated or anothers models when get contact with water automatically switch to "stand-by", whereby it will be in alert mode to detect any electromagnetic signal emitted by a radar device of another ship or aircraft. In this "stand-by" mode, it has a light that blinks every few minutes to indicate that it is really "listening".

Within 1 mile of the SART the screen is cluttered

It is interesting to note that the SART will be detected better the higher it is located on the liferaft and the higher the radar antenna is above sea level.

The SAR transponder (SART) has been developed which will respond to the normal 3cm X-band (9 GHz) RADAR fitted to merchant ships. It will NOT respond to 10cm S-band (3 GHz) RADAR. It is a short-range homing device, which enables ships and other suitably equipped craft to home on the source of the signal. This facility is in accordance with IMO Resolution A. 530(13) - Use of RADAR transponders for search and rescue purposes.

The SART can be either a stand-alone item of equipment or built into an EPIRB. When within RADAR range, the SART will respond to 3cm RADAR pulses by painting a line of blips extending outwards from the SART's position along its line of bearing on the RADAR screen.
Tests have shown that the operation of a SART inside the canopy of a life raft will significantly decrease its detection range, so every effort should be made to operate it from outside the canopy and as high as possible.

(2) Identification and confirmation of radar SART information
Its important to remind that personnel at the management level should take responsibility for supervising the bridge team during search and rescue operations. They should operate radar equipment in accordance with radar-SART characteristics so as to search the target in distress under various situations and acknowledge related radar SART information. They should also be able to acquire information via other available means and evaluate radar SART information in relation to the target in distress.
At the moment when the SART detects a radar, it will warn us by means of an acoustic signal and the light will flash rapidly. In addition, the device itself emits a "response" signal to the radar that has detected it.

As the SART gets closer the dots turn to arcs

As the range decreases the 'blips' will grow, becoming arcs. At about one mile range, these arcs will become a series of concentric circles. It has been found that the best results for locating a SART can be obtained by setting the search radar to a 12 miles range, before switching to six miles as the range decreases.
Obtaining an accurate bearing to the casualty becomes increasingly harder as the range decreases and the 'blips' become arcs, and impossible when the arcs become concentric circles. In poor visibility it may be necessary to make several passes from different directions and triangulate the bearings before the position of the SART can be accurately determined.
Once contact has been made with the Liferaft and the SART turned off, erect the radar reflector to aid location. The radar reflector MUST NOT be used at the same time as the SART.

.2 Identification, evaluation and acknowledgement of AIS-SART information
(1) Knowledge of AIS-SART .
A second type of SART is on the market and this is aimed at the A.I.S. system. The Automated Identification System transmits data on the VHF channels 87 and 88. The A.I.S. SART incorporates an onboard GPS which will transmit positional data every minute. Only vessels and shore stations fitted with an A.I.S. receiver will be able to detect the A.I.S. SART. Space based A.I.S. is in its early stages of developement and may also be able to detect the transmissions.
As well as updatable positional information the A.I.S. SART has a unique MMSI number that starts with 970 followed by 6 numbers making a 9 digit MMSI number

ie 970991234. The A.I.S. SART will be carried and used in a liferaft to indicate a survivor's position in the water.
AIS-SART information can be presented on compatible radar displays, which facilitate the identification and confirmation of the target in distress. Trainees should develop familiarity with the relevant knowledge of AIS-SART. During the course, Instructors should review the relevant knowledge related to AIS-SART, highlighting its operational features, the distinction and updating mode of information presentation, and the limitations of AIS-SART information.

(2) Identification and confirmation of AIS-SART information
Similar to the abovementioned identification and confirmation of radar SART information, officers should operate radar properly in line with characteristics of AIS-SART, so that the AIS-SART information can be properly acquired under various observation scenarios, and the position of the body in distress can be confirmed. Likewise, trainees should be able to obtain information with other available means and make a correct judgment on the evaluation of AIS-SART information in relation to the body in distress.
.3 Identification, evaluation and acknowledgement of MOB-AIS information
(1) Knowledge of MOB-AIS
Officers should gain a thorough understanding of MOB-AIS information, and be fully aware of its significance to SAR operations for persons overboard. During the course, a review of the relevant knowledge related to MOB-AIS, highlighting its operational features, the distinction and updating mode of information presentation, and the limitations of MOB-AIS information.
(2) Identification and confirmation of MOB-AIS information
Management officers should operate radar properly in accordance with the operational characteristics of MOB-AIS to acquire information under different observation scenarios, and to confirm the position of personnel overboard, as early as possible. Management officers should refer to the identification information obtainable from other means and sources, and make correct judgments on, and accurate assessments of, the MOB-AIS information.

4.2 Use of radar in SAR operations
This sub-topic mainly focuses on the application of radar in search and rescue operations, which includes determination of the search datum, search areas and track spacing, the monitoring and tracking of all SAR facilities, and coordination of search and rescue operations.
.1 Using information of radar and related SAR units to make SAR plans
(1) Determining the search datum based on the international conventions and guidelines related to SAR and radar information

Based on a review of the related content in SOLAS Convention, Chapter V and confirmation of the search datum part in the IAMSAR Manual, Officers should learn to launch a life raft or other floating markers near the search datum, observe its drift velocity and direction by the radar, then further estimate the drift speed and direction of the search object and modify the search datum.

(2) Determining and displaying the search area on modern radar on the basis of related resources

Based on a review of the relevant sections concerning the confirmation of search area in the IAMSAR Manual, officers should learn to set up the search area on the radar screen by using the overlap function of ECDIS and plotting function of modern radar for situational awareness and search and rescue operations.

(3) Determining the track spacing based on the international conventions and guidelines related to SAR and radar information

Based on a review of related content of track spacing determination in the IAMSAR Manual, to determine the track spacing in consideration of sea state, visibility, dimension of the search object and radar performance. The IAMSAR Manual does not include a special provision for the search patterns, however, in order to improve the efficiency of search and rescue, the OSC (on-scene coordinator) can direct ships to proceed in "loose line abreast", maintaining a track spacing between ships of the expected radar detection range multiplied by 1.5.

(4) Determining communication systems and equipment based on the international conventions, regulations and guidelines related to SAR

According to the relevant provisions in the IAMSAR Manual and ITU Radio Regulations, SAR plans should involve radio communication arrangements, and correct communication procedures should be followed at all stages of the search and rescue operations.

Search area coverage:

This can be reduced to the inter-related expressions:

Coverage Factor (C) ***Sweep Width (W)*** ***Track spacing (S)***

$$\text{Coverage Factor} = \frac{\text{Sweep Width}}{\text{Track spacing}}$$

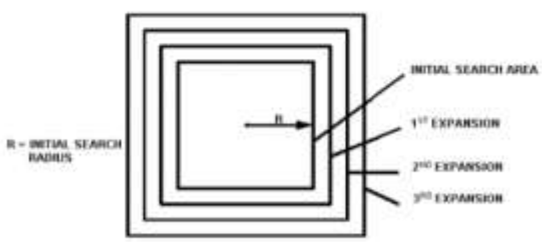
Higher coverage factors indicate a more thorough coverage. Higher values of C offer a higher probability of detection, however the higher POD is not proportional to the extra search effort required. Whilst a coverage factor of 1.0 is most desirable there are occasions when this is not possible. For such occasions an alternative approach must be used that balances the factors of available search hours, size of area and C. A coverage factor of less than 0.5 is unsatisfactory in itself.

Probability of Detection (POD)
The relationship between Sweep Width and Track Spacing determines the Probability of Detection (POD).

Table 5.2 Coverage data example

Search	Coverage Factor 1	Coverage Factor 0.5
Initial Search (R1)	78% POD	47% POD
First Expansion (R2)	95.6	71.9
Second Expansion (R3)	98.9	85.1
Third Expansion (R4)	99.7	92.1
Final Expansion (R5)	99.9	95.8

The Table 5.2 confirms that by making five searches of the initial probability area, each to a coverage factor of 0.5, the cumulative POD (95.8%) is only slightly less than if the same five searches had each been made at a coverage factor of 1.0, (99.9%). The search effort in the former case would have been considerably less in than in the latter and a significantly larger area surrounding the initial probability area would have been searched, albeit at a progressively diminished level of intensity.

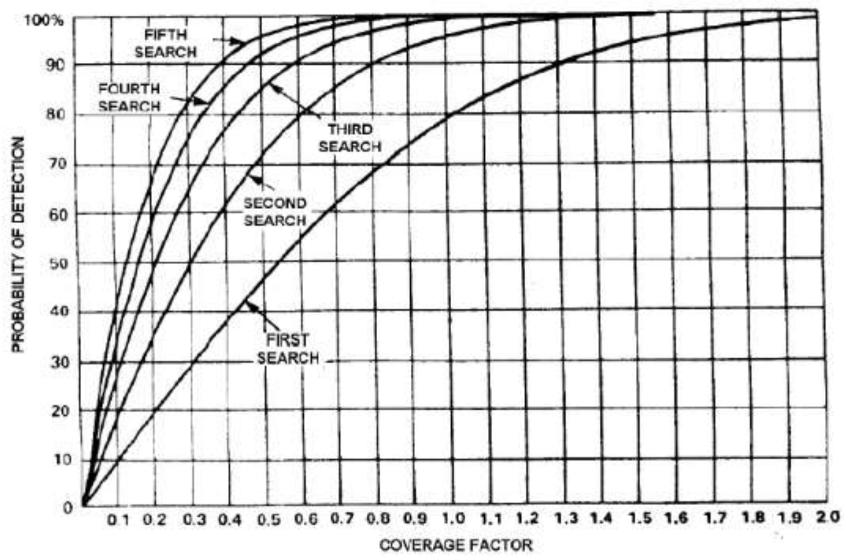


Search area expansion (not to scale)
(Drawing courtesy of NATSAR Manual)

For repeated searches of the same area, the cumulative POD is obtained by making use of the average coverage factor. The application of this concept results in a progressive increase in the POD of a target in the most likely sector of the search area by repeatedly searching the original area within progressively larger areas, a part of each overlaying the original. Thus there results an aggregate POD after successive searches of part of a probability area. For each successive search, the safety factor is increased, and the size of the probability area is enlarged.
It is not to be thought that early search effort should be restricted in anticipation of the benefits of the expanded search technique; these will take time to accrue, and time, in the rescue of survivors, is of the essence.

Probability of Detection

Figure I-12 - Probability of Detection



When using the Graph the POD for any particular search is obtained by reference to the appropriate Search graph line depending on the search conditions. For repeated searches of the same area, enter the graph with the average coverage factor and refer to the graph line relevant to the overall number of searches to obtain cumulative POD. The results are shown as:

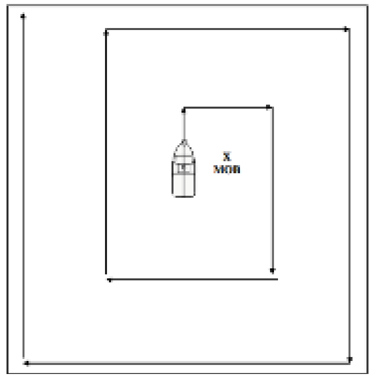
1st Search	Coverage Factor 0.5
2nd Search	Coverage Factor 0.7
3rd Search	Coverage Factor 0.3
4th Search	Coverage Factor 0.2
5th Search	Coverage Factor 0.3

Over 5 searches, the average coverage factor = 0.4

In entering Graph 2 with an average coverage factor 0.4, the cumulative POD after five searches may be read off from fifth search graph line as 92%.
The projected value of the POD may be used by a SMC in deliberation of track spacing. Use of POD may also be conveniently made in describing the results of a Search to interested persons not familiar with search planning techniques.

Search Patterns:

Expanding square system – one vessel



This system starts at the datum point established earlier. The diagram shows the pattern, distance between the tracks will depend on height of lookout and weather conditions but should be such that each sweep should double up on detection.

.2 Conducting SAR operations by radar information

Based on a review of the related contents concerning factors affecting radar detection range in model course 1.07, officers should develop the ability for command decision-making, and the ability for managing standard operation of radar and effective use of radar resources in the SAR operations, in order that the echo of the distressed craft can be identified in the clutter environment with full consideration given to the safety of navigation.

In case the distressed craft is found in the preliminary actions of SAR, the OSC is in a position to assign appropriate crafts to participate in on-scene rescue according to the specific circumstances of the distressed craft, and ensure safety by visual and radar lookout. In the process of approaching the distress location, more lookouts should be assigned in the fore-and-aft as well as both sides of the ship. In addition, radar should be well modulated for optimal effects.

In response to different distress categories, radar can be used to predict the drift direction and drift speed of the distressed craft and appropriate manoeuvres can be applied to save the search object.