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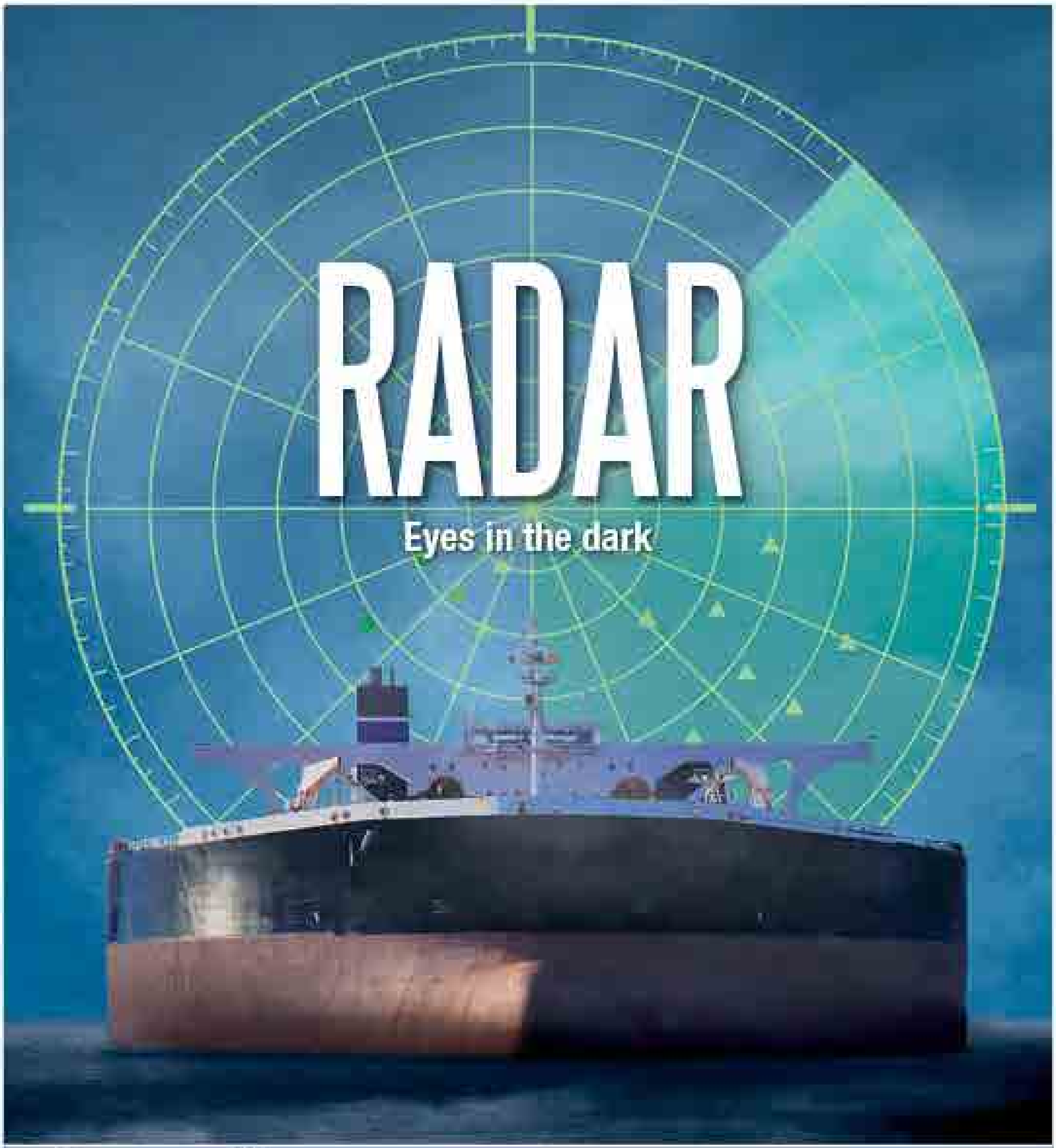
THE NAVIGATOR

Inspiring professionalism in marine navigators



The Nautical Institute
Royal Institute of Navigation

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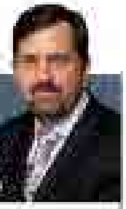
NAV BRIEF



David Patraiko FNI
Director of Projects, The Nautical Institute

Radar re-examined

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, colour 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 ship-centric. 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 familiarisation 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!

We hope this edition of *The Navigator* inspires you to reflect on the use of the radar and to share these thoughts with your fellow navigators. This, and all other issues of *The Navigator* are available for free download from www.nautinst.org/en/Publications/the-navigator/

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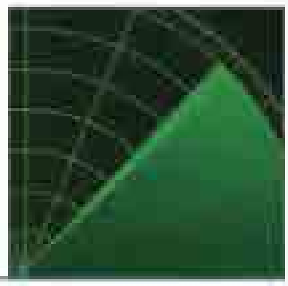

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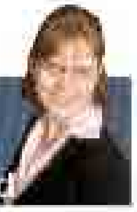

Emma Ward

If you would like to send us your response, comments or ideas about anything in this issue, or the next, please contact the editor at navigator@nautinst.org

In the last edition of *The Navigator*, we discussed ECDIS. For this issue, we asked the Nautical Institute's Sea-going Correspondence Group for their personal opinions and experiences of radar. The responses, from officers at all stages of their careers – from third mate to Commodore – cover a wide range of topics.

We are always interested in hearing your views on the important topics discussed in this publication. If you would like to send us your response, comments or ideas, please contact the editor, Emma Ward at navigator@nautinst.org, or look out for the LinkedIn discussion. We look forward to hearing from you.

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Some thoughts on...

Verification

Never take anything seen on a radar screen at face value. Always crosscheck either visually or with an alternative independent system. Never assume!

Collision avoidance

On vessels fitted with two radars, I would advise that one should be dedicated to navigation and the other to collision avoidance.

Tracking too many targets can mentally overload the navigator in high traffic areas. Only targets of interest need to be acquired and tracked.

Navigation

Radar returns are not an exact match for charted features, and errors are frequently not quantifiable. Everyone needs to practise!

I use radar, along with visual lookout, as the primary method for navigating our district. I consider ECS, AIS etc. as supplementary aids.

Identifying targets

Utilizing target trails of suitable length (looking at wake) with relative vectors (looking-ahead) provides the best visual information about a target.

It's great to be able to plop a plot on anything and see how the target compares when it pops up on the ECDIS screen. Brilliant!

Using vectors

When the accent is put on navigation, then it is important to have a true/relative motion and true vectors. True vectors with a proper set of time/length could render quick and adequate information regarding the ship motion with regard to shore and shore/fixed hazards.

A vector should be short enough to help readily show direction, but not so long as to be confused with the ship's heading marker.

Training and familiarisation

Trial manoeuvres are both useful and used – a real lifesaver.

A lot of self-teaching goes on, and some radar displays are more user-friendly than others. If an unfamiliar user wants to find, say, a simple tool and has to search down through a number of menu layers to access it on a dark night on an unfamiliar vessel, this can present its own hazards.

Collision course

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. Here, members of The Nautical Institute's Seagoing Correspondence Group (SGCG) offer advice on their own preferred ways of managing radar for collision avoidance.

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.

RELIABILITY

While relative bearings/vectors are highly reliable and accurate, true vectors or decision support tools that rely on inputs, such as speed, position, or gyro data, could be inaccurate if the input data is compromised. Interpreting radar returns is still an art and not an exact science. In other words, assume nothing and always try to check visually, or by an alternative independent system.

RANGE

It is crucially important to routinely change ranges when detecting and monitoring targets. Use of the longer range settings gives good prior awareness of more distant but relatively large targets, whereas shorter range settings are necessary to detect and discriminate virtually all targets closer to own vessel. The use of offsets is also encouraged. According to one member of the SGCG, "operating with centre offset to maximise look ahead is always preferred for both navigation and collision-avoidance radars."

TUNING

Radars have options for automatic tuning of gain, STC (sea clutter), FTC (rain clutter), and AFC (tuning control). However, the automatic settings of these controls will not necessarily give the best performance in all conditions and so manual adjustment can be important. Professional navigators must ensure that they are proficient with the use of these controls and be familiar with them for every ship they sail on.

Poor manual tuning is a real hazard, as is failure to recalibrate the radar when conditions change. Best practice is to always check the settings of all controls before assuming a watch.

TWO RADARS: BETTER THAN ONE?

Using one radar for navigation and the other for collision avoidance is best in some circumstances, while in others, it may be beneficial to use one radar for greater range and the other for close-range detection. It is important, too, to recognise the difference between S-Band (3GHz/10cm) and X-Band (9GHz/3cm) radars, both of which are required on larger vessels. S-Band is generally preferable in adverse conditions, such as fog, rain and heavy seas, while X-Band is noted for good angular discrimination, required in pilotage waters, for example. On ships where the radar displays can be inter-changed, such as on Integrated Bridge System workstations, it is essential to know which radar system (S or X) you are using at any time, and the expected performance parameters for each.

DISPLAY ORIENTATION

Shipboard radar displays can be configured in a range of orientation modes (head-up, North-up, course-up) each offering benefits and hazards. Head-up display allows easy association with views from the bridge windows or from electronic charts in head-up mode, whereas North-up gives easy association with paper charts or electronic charts in North-up mode. These choices may also be affected by the area the ship is in, such as pilotage waters or open ocean, and should always be coordinated with all members of the bridge team. As one experienced pilot advises, "learn how to use a head-up unstabilised display, so that if/when all the secondary inputs fail, you still have a useful tool."

MODE OF DISPLAY

Radar and AIS data can only be used safely if there is a good understanding of both true and relative motion. Poor understanding can result in a major collision! Displayed vectors on radar-tracked targets and AIS-acquired targets can be set to be either true or relative. Again, the combination of settings and uses will depend on the individual circumstances. One mate suggested that, "for collision avoidance, the use of relative vectors and true trails is most useful."

USE OF AIS

Radar and AIS data can be very effective if used together, either manually or automatically (association). Benefits and weaknesses of operating radar and AIS together include:

- Two independent ways of detecting targets
- Two independent estimates of a target's range, bearing, course and speed
- Radar detection of targets that do not carry AIS
- Clear AIS transmissions, almost unaffected by clutter
- AIS can be 'seen', whereas radar detection can be impossible, e.g. behind islands and headlands
- Radar doesn't have to rely on external data sources, unlike AIS
- AIS can indicate changes in course and speed quicker than radar can detect them
- AIS can often provide more information about a target

INFORMATION OVERLOAD

Information overload is a serious danger. Modern radars can display a wide range of additional information and symbols, but too much information can lead to confusion and non-detection of targets. Such additional information can come from ARPA, AIS, vectors and vector lengths, target names and information, guard zones, exclusion zones, chart information, etc. As the shipping industry migrates towards greater use of Integrated Bridge Systems (IBS), Integrated Navigation Systems (INS) and eNavigation, the need to manage portrayed information will become ever more essential. Never forget that it is easier to detect targets on a relatively clear display.

Further information about using radar for collision avoidance can be found in the Nautical Institute's guidebook, *Radar and AIS* by Dr Andy Norris.

A navigator tasked with setting up the radar prior to arrival or departure will need to make a number of decisions about which of the radar's features and modes of display to use. This article addresses some of the issues a navigator might consider when using radar for navigational purposes, and is designed to complement the information about using radar for collision avoidance on pages 4 and 5.

NAVIGATING THE RADAR

ORIENTATION MODE

There are three orientation modes the navigator may choose from when setting up the radar: North-up, head-up and course-up. A North-up display is often preferred, as the orientation of the radar picture will match that of a paper chart and so also matches most peoples' mind-set of an area. In head-up mode the 'up' direction of the display represents the vessel's heading; in course-up mode it represents the direction which has been input as the vessel's desired course. In normal use all three modes make use of the ship's gyro-compass to reference the display, which is known as azimuth stabilisation. However, if the gyro-compass becomes inaccurate or unavailable the radar will have to be set to the head-up unstabilised mode. This could cause the smearing of land and other echoes with alterations of course.

MOTION MODE

Two motion modes are provided – True and Relative. In True Motion the displayed position of own ship moves at a scaled speed across the display that corresponds to the vessel's actual motion. In Relative Motion mode the displayed position of own ship is static. When off-centred, this provides maximum lookout ahead, as well as possible early warning of rain showers/ squalls, landmarks, wheel over points and, of course, traffic.

STABILISATION MODE

There are two stabilisation modes – ground and sea. Ground stabilisation means that the display is referenced to the seabed by GNSS or through a twin-axis Doppler log. For sea stabilisation the display is referenced to the sea current that own ship is experiencing, typically based on SDME measurements. It is generally accepted that the ground stabilised mode is more useful for normal navigation, especially when combined with setting tracked targets to show their True vectors. However, since set and drift affect heading and aspect, ground stabilised displays should be used with caution where target tracking is concerned. Having a 'predicted' ground track in confined waters is especially useful, particularly where visual information and cues are limited or unavailable, such as in fog.

With ground stabilised radar, all stopped targets will show the set and drift, which is ideal for navigation in channelled waters with significant tidal streams. However, the effects of current will vary across the observed area.

TARGET TRAILS

Target trails can be set to be either True or Relative, whatever motion mode the display is set to. In coastal and confined waters, navigators often select Relative Motion True Trails (RMTT), as it provides the illusion of true motion while retaining the advantages of relative motion.

With ground stabilised radar, all stopped targets will show the set and drift, which is ideal for navigation in channelled waters with significant tidal streams. However, the effects of current will vary across the observed area. Since set and drift affect heading and aspect, ground stabilised displays should be used with caution where target tracking is concerned.

POSITIONING

For decades, radar has been a tremendously reliable tool for ascertaining the range and bearing of fixed and floating objects. The variable range marker (VRM) and electronic bearing line (EBL) facilitate a quick and easy check of the vessel's position in coastal waters. By simply extending the VRM and rotating the EBL to a number of conspicuous points on the radar picture, and laying off those range and bearing lines to the corresponding charted objects, the navigator can quickly establish the ship's position. This applies to both paper and electronic charts.

However, it is important to note that any position plotted is historical – a record of where the vessel once was. It provides no indication of where the vessel is likely to be. Only by creating an estimated position (EP) using the ship's course and speed will a future position become clear. On ground stabilised settings, the true vector or 'predictor' provides a real-time EP. The vector length can be adjusted from a few seconds, typically up to 60 minutes or more. When sailing in shallow waters or close to land, this 'predictor' can provide early warning of deviation and prompt early corrective action. At anchor, a true vector set at 60 minutes or more could provide an early indication of dragging.

THE VARIABLE RANGE MARKER (VRM) AND ELECTRONIC BEARING LINE (EBL) FACILITATE A QUICK AND EASY CHECK OF THE VESSEL'S POSITION IN COASTAL WATERS.

OFFSET VRMS AND EBLS

In addition to providing a range and bearing from the vessel's own position, EBLs and VRMs can be offset (carried or dropped elsewhere onscreen) to provide a course to make good and a distance to go to a pre-determined position. This is extremely useful when approaching an anchorage or waypoint, or determining a course to steer when, for example, the vessel makes a planned departure from track. The carried EBL also serves as a parallel index line if required and can provide an indication of an object's bearing further along the ship's course, which can then be visually confirmed.

PARALLEL INDEXING

The use of parallel indexing to monitor cross-track distance is key to navigation. On modern radar sets, four or more index lines are typically available, often in different colours, enabling the navigator to index present and future courses. Parallel indexing allows an almost instant reaction to any unplanned deviation from course, as well as continuous monitoring of the vessel's progress in relation to its track. The great advantage of parallel indexing is that it requires nothing more than the relative track of a fixed object parallel and reciprocal to the vessel's own track. Remember the saying: "to safely get by, use your PI."

IN SUMMARY

Radar offers the navigator many useful functions for pilotage and coastal navigation:

- Parallel indexing and relative trails – for track monitoring and control
- True vectors – to indicate the vessel's ground track in steady state conditions
- ARPA (also known as target tracking) – to acquire fixed objects to ground stabilise (echo referencing)
- Offset EBL and VRM – to provide a leading line, course to steer, distance to go etc.

WATCHOUT

In this series, we take a look at maritime accident reports and the lessons that can be learned.

Fogging up the view: inadequate radar use causes chaos

What happened?

The departure of a bulk carrier was delayed due to thick fog. When conditions improved slightly, the vessel set off, but crossed the river quicker than anticipated. The pilot did not monitor the speed, and was not familiar enough with the onboard radar equipment to use it correctly. He and the bridge crew soon lost situational awareness in the fog and did not carry out a continuous radar watch as per the guidelines. The vessel collided with some moored barges before grounding in shallow water. Damage was caused to the hull and shell plating that took two weeks to repair.

Why did it happen?

Investigations into the incident found that the loss of situational awareness of the bulk carrier's bridge team was instrumental to the grounding, along with their lack of knowledge about how to use the onboard radar equipment. The pilot's attempt to establish the vessel's position and speed using the radar was unsuccessful as he was not familiar with the set. Inappropriate settings on the radar meant it would have been difficult to identify the vessel's position due to clutter.

In addition, the roles and responsibilities of the bridge team had not been confirmed before the vessel left its berth, despite the tricky conditions caused by the thick fog. As a result, no-one was instructed to keep a continuous radar watch, and the course and speed of the bulk carrier were not monitored closely enough during the manoeuvre. The bulk carrier quickly ran into trouble and the fog caused the team to lose situational awareness, meaning that the erroneous course was not corrected, nor the alarm raised in time.

The issues

> Lack of situation awareness
> Unfamiliarity with the onboard radar system
> Ineffective use of radar
> Poor bridge resource management

What changes have been made?

> Recommendations were made to improve bridge team performance, especially when operating in conditions of poor or restricted visibility
> Advice was issued to pilots to take care when setting up a radar with which they may be unfamiliar
> Restricted visibility berthing and unberthing exercises were added to simulator training sessions

A man's world? How one woman is successfully building a career at sea

In this series, *The Navigator* speaks to current navigational personnel about their motivations, careers to date and thoughts for the future. In this issue, Second Officer **Fani-Sotiria Provatari** discusses the challenges facing women at sea and reveals what, for her, are the greatest rewards of the navigator's profession

What triggered your interest in building a professional career at sea?
From a young age, I always had a passion for traveling and had hoped that I would some day have the chance to explore the entire world. This career path, albeit demanding and a tough slog, certainly has given me this opportunity.

How did you end up in your current position?
I began as an apprentice onboard a passenger ship. While one of the more stimulating aspects of my position was the interaction I had with passengers, it was the seamless communication and effective teamwork between the other crew members and myself that spurred me on to continue in this career.

Where do you see your career going from here?
I do have high hopes, even though building a career at sea is particularly difficult for women, given the predominantly male environment at every tier. I would like to pursue further training, as appropriate, to potentially help me take my career ashore, working either for a shipping company or for the Coast Guard.

How do you feel during a navigational watch-keeping shift on the bridge?
There is pressure and a lot of responsibility that makes it imperative to do my job properly. I feel satisfied, especially when my supervisors are happy with me and the way I perform my duties while keeping watch.

What do you consider as the most important reward of your work onboard?
To be recognised as being good at what I do and to have my worth appreciated by others. To gain new knowledge and experiences.

In your opinion, what are the greatest challenges for bridge officers in the future?
Bridge officers must prove their knowledge and competence on a daily basis. There is intense competition, especially among women, to make it in a profession dominated by men.

BRIDGE OFFICERS MUST PROVE THEIR KNOWLEDGE AND COMPETENCE ON A DAILY BASIS

Dr Andy Norris FRIN FNI

Reassessing radar: then, now and in the future

Dr Andy Norris, an active Fellow of The Nautical Institute and the Royal Institute of Navigation, looks back at the history of radar and wonders how much it has really changed over the years.

Back in 1946, the first requirements for civil marine radar were laid out to manufacturers during an international meeting on radio aids to marine navigation. Since then, it is remarkable how many of the basic performance requirements for radar have really not changed, as the table to the right shows.

Requirement	1946 standards	Latest IMO requirements (2004)
Basic in-the-clear detection ranges:		
Shoreline rising to 200 ft /60 metres	20 miles	20 NM
Second class buoy/channel marker	2 miles	2 NM (X-band), 1 NM (S-band)
30 ft/10 metre vessel	3 miles	3.4 NM (X-band), 3.0 NM (S-band)
Bearing accuracy	1°	1°
Bearing discrimination	3°	2.5°
North-up stabilisation capability	Yes	Yes

The 1946 performance requirements matched not only what was technically feasible at the time, but also what would provide highly useful information for the marine navigator. The latest requirements, updated by the International Maritime Organization in 2004, only really differ with regards to how information has to be shown to the user, taking advantage of the advances in modern digital processing and display technologies. In general, the basic requirements for target detection performance have hardly changed at all, although some useful enhancements have been made to the accuracy of the system.

Today's user courses for marine radar spend a lot of time on the performance limitations of radar, and rightly so. One key point is that targets can become invisible when conditions at sea deteriorate, due to the effects of sea and precipitation clutter. The statutory range requirements for marine radar are labelled as 'in-the-clear detection ranges'. IMO does not specify the allowable degradation in adverse conditions. However, it does insist that the performance degradation for certain defined rain and sea-state conditions is mentioned in the equipment's user manual.

Taking degradation for granted in this way seems to be totally at odds with what navigators need. After all, when visual conditions deteriorate, the instinct is to rely more and more on the radar. While technology has always aimed to lessen these effects as much as possible, the potential for significant further improvement has been somewhat ignored in recent years.

Military precision?

Basic concepts for further improvements were developed many years ago by the military, in order to be able to see such things as submarine periscopes. It was realised that, if the received signal could be precisely compared to the actually transmitted signal in both amplitude and phase, then the effects of clutter could be reduced by a factor of hundreds or even thousands. Today's implementations of so-called *coherent* radars, using modern semiconductor devices, can make a very sophisticated system much more affordable, even for the commercial market.

Unfortunately, the current IMO requirements for radar do not promote significant moves in this direction. In some ways, we still have a 1940's mindset of what radar can and cannot do for us. As with all onboard equipment, users of radar should be encouraged to express their own thoughts if they see a need to improve performance.

Physics and affordability obviously get in the way of creating the perfect product. However, when advances are possible, we should do all we can to meet users' needs. Although such radars are more expensive to buy than standard systems, they are more likely to reduce accidents and improve navigational efficiency, therefore representing valuable cost savings, financial and otherwise.

TAKE 10

The focus has been firmly on radar in this issue of *The Navigator*. Here are 10 key aspects to remember about this vital tool

1
Reliable radar
Radar has earned its place as a tried and tested ‘best friend’ to the navigator due to its reliability and independence from external systems, such as GPS.

2
Two for the price of one
The two primary uses of radar are for collision avoidance and for navigation. Professional navigators need to know how to use radar effectively for both tasks.

3
Know your tools
Modern radar has many sophisticated functions and options. Navigators need to know how to use these tools, their limitations and how to operate without them if need be.

4
Check, check and check again
Never take anything seen on radar at face value. Always crosscheck either visually (look out the window) or with an alternative independent system. Never assume!

5
Familiarity breeds success
Understanding how to use radar requires both training and familiarisation. Regardless of how well you may know radars in general, when you join a new vessel it is essential to familiarise yourself with specific onboard radar units prior to assuming watch.

6
Keeping in tune
Automatic tuning can be useful. However, knowing how and when to use manual tuning should be part of familiarisation. Tuning functions should be checked before assuming each watch.

7
Target practice
Continually monitor different ranges and consider the use of screen offsets in order to detect all possible targets.

8
Be band aware
Know the difference between S and X Band radars. Know which is being displayed and know how to use each strategically to best effect.

9
Team talk
Mentoring – there is not usually one best way to set preferences for a radar display, and the choice of display options changes with navigational circumstances. Discussing these options amongst the bridge team and Pilot can provide an excellent learning experience for all navigators – young and old.

10
Be alert to advancements
Radar technology and performance are advancing. Be alert to these new systems and encourage their application onboard where financially justified.