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THE NAVIGATOR

Inspiring professionalism in marine navigators

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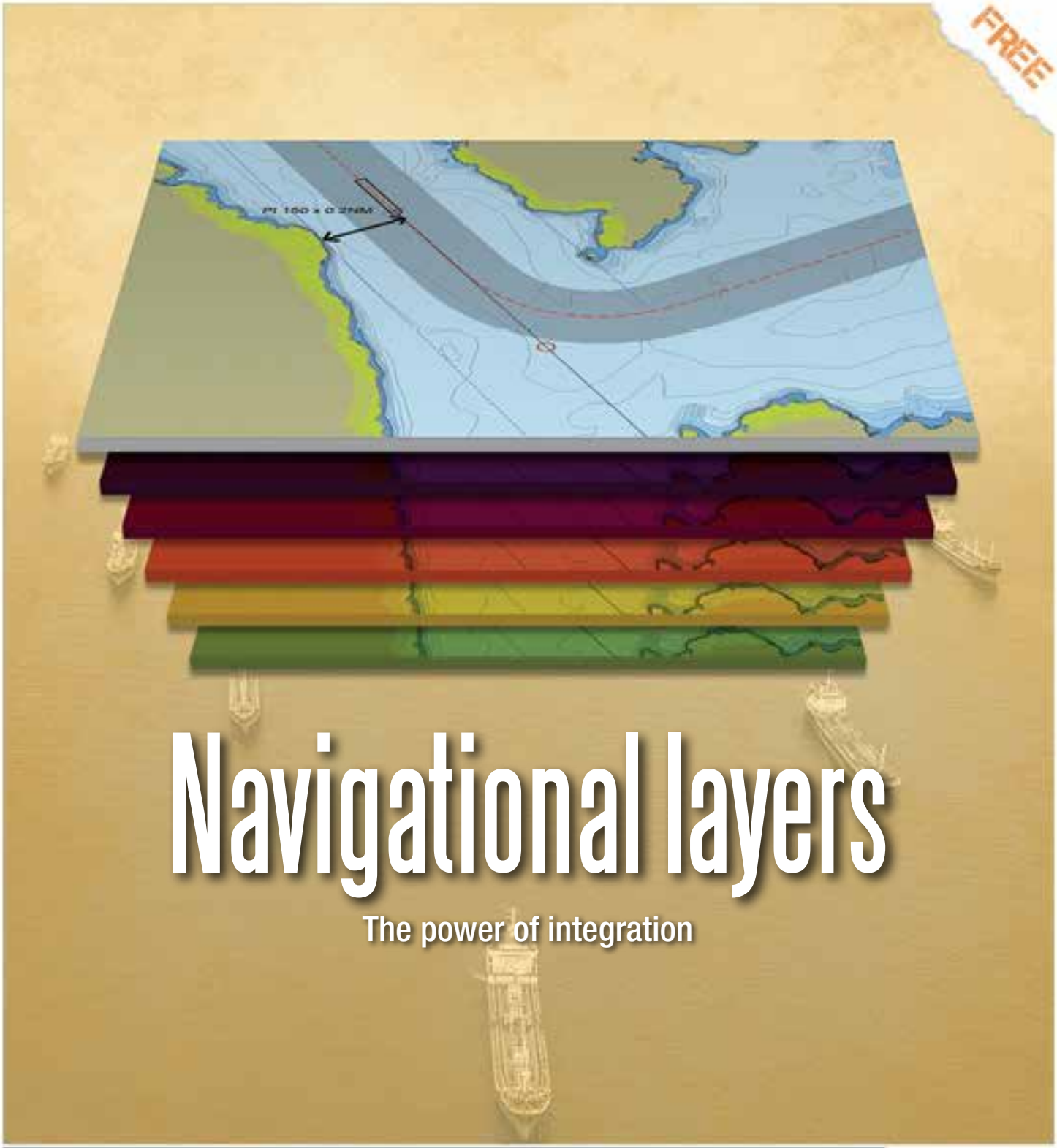

Navigational layers

The power of integration

A free publication by **The Nautical Institute** in association with the **Royal Institute of Navigation**

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NAV BRIEF

David Patraiko FNI
Director of Projects, The Nautical Institute

A multi-layered approach

We're all familiar with using radar and ECDIS on their own, and these two systems are often viewed as being separate, independent and employed for separate tasks. Most modern bridge systems, however, have functions allowing navigators to share information between the two devices, often incorporating Multi-Function Displays (MFD) to show different 'layers' (overlay/underlay). If done well, this can improve situational awareness and provide backup checks for critical features. Done poorly, it can also present great risks.

Using ECDIS on its own, it is very easy to become over-reliant on GPS/GNSS. If your GPS is inaccurate, you may not realise if your own ship's position is wrong. Radar, on the other hand, is excellent at identifying information in relation to own ship's position, but less so at showing how that position relates to navigational hazards below the water.

Traditionally, the navigator's role was to assimilate these views manually, but with the advent of electronic integration these views can now be combined on screen. Managing 'layers' from these systems can provide valuable confirmation of GNSS accuracy, Gyro integrity and proximity to navigational hazards both above and below the water.

This issue of *The Navigator* looks at the use of 'layers' to support and enhance good decision-making. It explores how a radar image of the coastline can be aligned with the chart image of the same land to check the accuracy of GPS – a very comforting sight when the two line up. We also explore how displaying the outline of a Traffic Separation Scheme (TSS) on a radar image improves situational awareness and how the traditional practice of Parallel Indexing (PI) is still valid and effective. These articles highlight how mismanaging layers can mask critical information or overload the user with information, hampering good decisions.

There is no single 'best solution' to manage navigation layers. It is up to the navigator to understand the options available, to assess the situation and to choose the information that is most useful in that particular moment.

Modern navigation systems also have a variety of options for manually plotting positions and using PI. Practise using them on a regular basis to make sure you have the competency when you need it.

Unfortunately there is a wide discrepancy in how systems operate (something The Nautical Institute is working on) so make sure you are familiar with the operation of systems on your own ship to get the maximum benefits. As always, it's good to discuss these issues with your bridge teams in order to share your knowledge and learn from other. Please learn from this issue of *The Navigator*, share it with your colleagues and enjoy.

INSIDE THIS ISSUE

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ALL AT SEA

Emma Ward

We welcome your news, comments and opinions on the topics covered in *The Navigator*

If you would like to get in touch with us, please contact the editor, Emma Ward at navigator@nautinst.org, or look out for the LinkedIn discussion. We look forward to hearing from you.

Not (just) for Navigators

I was surprised seeing one of my crew one day looking at your magazine. He was my mess boy and just starting to make his career in the field of maritime transportation.

As a Filipino seafarer, the first step to start your career to embark on an ocean-going vessel is to be employed as a deck boy, engine boy or mess boy, and that's how he planned his future – to start on the lowest rank.

This stage did not discourage him from learning and levelling up. The way I see it, reading and looking at your magazine will speed up his progress to be a future Merchant Marine Officer.

Captain José Jay Paz

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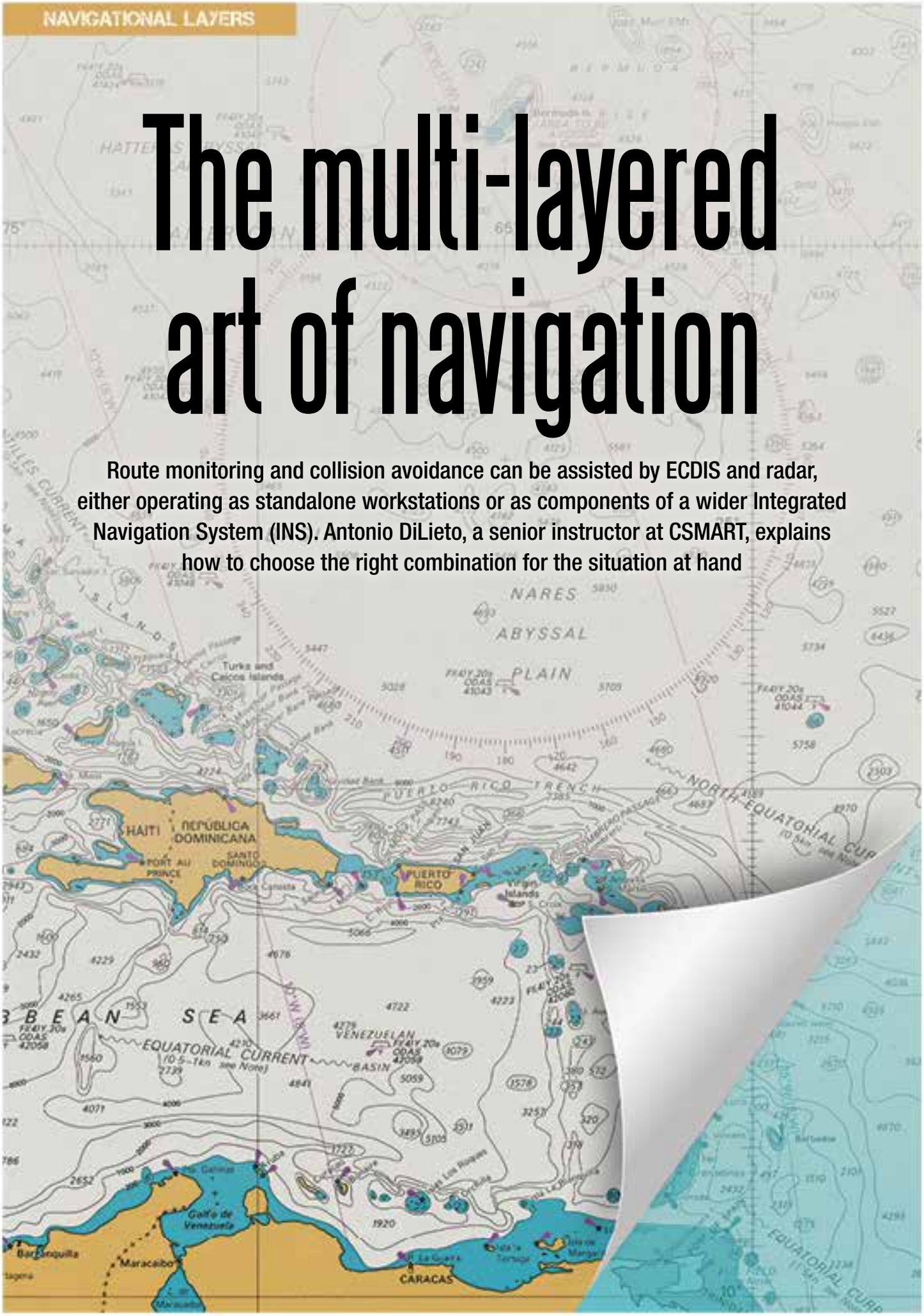
The multi-layered art of navigation

Route monitoring and collision avoidance can be assisted by ECDIS and radar, either operating as standalone workstations or as components of a wider Integrated Navigation System (INS). Antonio DiLieto, a senior instructor at CSMART, explains how to choose the right combination for the situation at hand



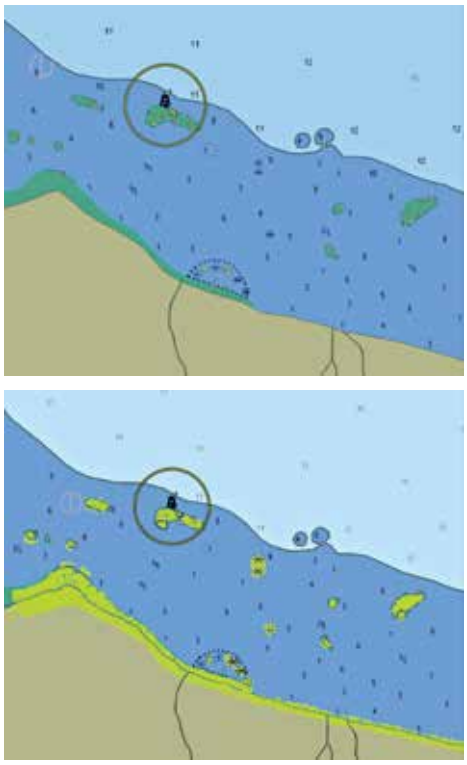
So-called radar and chart 'overlays' are a key capability of an INS. The purpose of the INS is to enhance safe navigation by integrating the different functions needed to avoid geographic, traffic and environmental hazards. By combining and integrating radar and ECDIS functionalities, an INS helps the navigator not only in terms of route monitoring and collision avoidance, but also by enabling them to monitor the integrity of the navigation sensors onboard.

Let us explore how using different layers on the INS can add value in three different scenarios:

1. Route monitoring on ECDIS with radar video layer

ECDIS route monitoring can be enhanced by adding a radar video layer as an 'underlay'. This allows the navigator to compare – at any point in time – the actual exposed part of a dry area, or an isolated danger which uncovers at low water, with their positions as shown on the Electronic Navigational Chart (ENC).

On ECDIS, the ENC will always be displayed with priority over the radar layer, so doing this will not affect the full ECDIS monitoring capability. The radar layer will also not obscure ENC features like coastline, awash rocks, or dry areas at low water.



Top image shows ECDIS alone; bottom image shows chart with radar underlay

BY COMBINING AND INTEGRATING RADAR AND ECDIS FUNCTIONALITIES, AN INS HELPS THE NAVIGATOR NOT ONLY IN TERMS OF ROUTE MONITORING AND COLLISION AVOIDANCE, BUT ALSO BY MONITORING THE INTEGRITY OF THE NAVIGATION SENSORS

Having the radar target echoes as an underlay to the ENC may also enhance the ECDIS route monitoring capability. This allows the navigator to consider actual traffic if planning a deviation from the planned track.

2. Collision avoidance on radar display with ENC layer and planned track

The use of radar for collision avoidance can be enhanced by setting an ENC layer with the planned track as an underlay on the radar. This can boost the navigator's ability to evaluate options and make decisions based on the sea room available. Be careful; the radar video may obscure ENC features such as the charted coastline or an awash rock symbol.

To avoid excessive clutter on the radar display, you should carefully consider the amount of ENC information to be included in the underlay. In doing so, the navigator is not constrained by a minimum required display of ENC features. This is different from ECDIS route monitoring, which requires standard display as a minimum.

3. Sensor integrity monitoring on radar display with ENC layer and planned track

Monitoring the integrity of other sensors is a key functionality of an INS. For example, using ENC data as an underlay to radar displays can help detect any bias or failure from position and heading sensors.

A mismatch between the radar video (coastline, targets, navaids) and the corresponding ENC features indicates that there is a GNSS position bias. The planned track will also be affected by the same shift. If this happens, the navigator should rely solely on the radar video. They should deactivate the ENC layer and the planned route, which might be misleading. Instead, they will have to rely on parallel indexes (PIs) on the radar display and plotting positions manually on ECDIS using radar distances and compass bearings.

If there is a GNSS failure, the INS might automatically switch to Estimated Position mode. In such a mode the mismatch between the radar video and the ENC layer may not be immediately visible, but it may grow over time, depending on the accuracy of speed and heading inputs.

A gyro bias on the radar display will also generate a mismatch between the radar video, the ENC layer and the planned track, but of a radial nature. The radar video will rotate, producing a mismatch that increases with the distance from own ship. A reasonable response to avoid potentially misleading information is to deactivate the ENC layer and the planned track, navigate with the radar head-up and rely on radar distances, as well as on GNSS positioning, speed and course over ground available on the ECDIS. Essentially, you are acting as if the gyro had failed. In fact, a gyro failure would put the radar automatically in head-up display and deactivate the ENC layer, forcing the navigator to rely on GNSS positioning, speed and course over ground, all of which are still available on ECDIS.

Good practice

There is no single best way to use navigation layers on radar displays and ECDIS. Every situation will require dynamic adaptation to specific combinations of settings. However, there are some guiding principles to help you take advantage of navigation layers while operating an INS:

- Actively monitor both ECDIS and radar displays with the respective radar video and ENC layers.
- Customise the ENC layer on radar displays. Remember, information overload may compromise target detection and tracking for collision avoidance. Less is more!
- On a radar display, important ENC features may be covered by the radar video. This means you cannot use ENCs underlaid on radar displays to replace route monitoring on ECDIS.
- Actively monitoring the mismatch between radar video and ENC layers will help detect sensor bias and failures in good time
- Be ready to react to sensor failure by deactivating ENC layers on radar displays and by seamlessly transitioning to PIs and manual position fixing on ECDIS.

Drawing the line

A prudent navigator always remains aware and in control of own ship's position and motion. As a good practice, never rely on just one means of position fixing or verification. Capt Zakirul Bhuiyan FNI and Captain Jaikar Sohal AFNI from Warsash Maritime School explore some of the tools at your disposal

For decades, navigating officers have been employing techniques such as Parallel Indexing (PI) and position fixing using Lines of Position (LoPs) for monitoring the ship's position with respect to its planned track. Advances in electronic navigation, especially the introduction of ECDIS, have made these techniques even more significant.

Without a doubt, ECDIS has enhanced navigators' situational awareness by keeping them aware of the vessel's real-time position in relation to the surrounding navigational dangers. However, the performance of ECDIS is largely dependent on the performance and accuracy of the mandatory sensors measuring heading, position and speed. There have been many incidents in the recent past that highlight the vulnerability of sensors such as the Global Navigation Satellite System (GNSS). The use of navigation techniques like PI and LoPs, which can be set up as layers on an Integrated Navigation System (INS), helps to build navigational resilience and improves situational awareness.

The power of Parallel Indexing

Parallel Indexing is a very useful technique that allows the watchkeeper to react almost instantly to any deviation from the planned track and to constantly monitor whether the vessel is 'right of the track', 'left of the track' or 'on track'. PI relies on the fact that the relative track of a fixed object is the reciprocal (i.e. exact reverse) of the vessel's ground track.

During the passage planning stage, certain fixed charted objects are chosen as indexing targets or references. They must be good radar targets, clearly visible on display at the appropriate ranges. As the vessel proceeds along its track, the PI moves with it, maintaining its position on the target. Should the vessel move off its track, the PI will also move away from the reference target. This deviation is readily noticeable. It prompts the operator to make timely adjustments to the heading to bring the vessel back on track and the PI back to the correct reference target.

Use of index lines for position monitoring and course alteration

The PI technique offers many advantages:

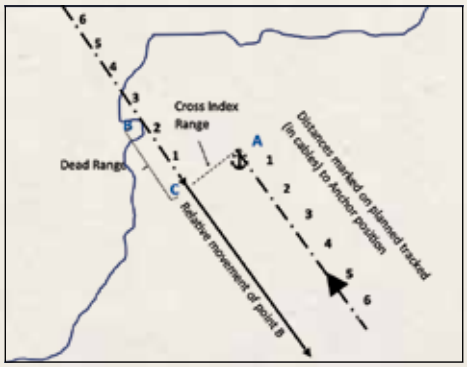
Position monitoring on track: It provides real-time monitoring of the vessel's position. Other methods like position fixing give the history of the vessel's positions. PI lines can also be used as the clearing bearings to keep the ship in safe waters

Course alteration: The use of wheel-over PIs can help to execute large alterations effectively

Collision risk assessment: A PI line aligned with a number of successive plots of the target can provide an indication of the risk of collision. This is especially useful on radars without ARPA

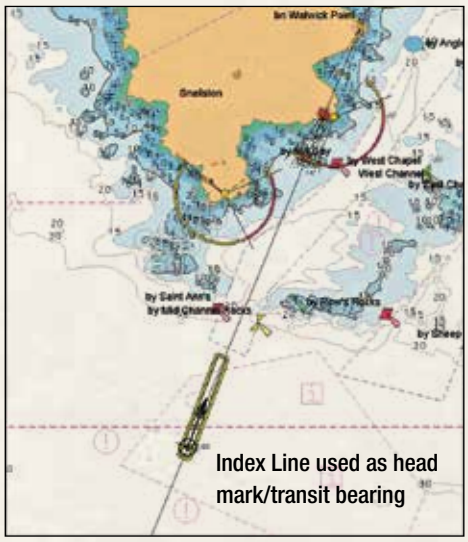
Using index lines with VRM for marking relative track of targets for determining closest point of approach

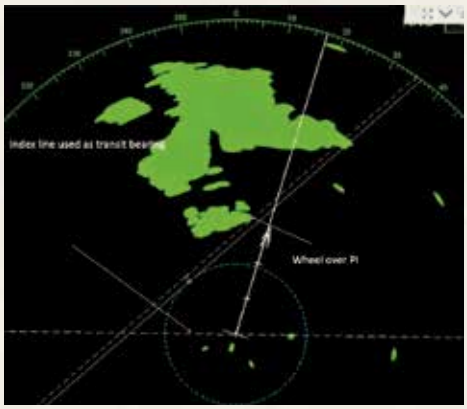
Anchoring: A PI line can be used along with a Variable Range Marker (VRM) adjusted for dead range to anchor a ship in a controlled manner. (See diagram below)



Anchoring using PI line and dead range on radar

Zero index line: The zero index line, i.e. PI line passing through the centre of the radar's plan position indicator, can be used as a marking line for steering, or as a transit line to take transit observation of any object for alteration





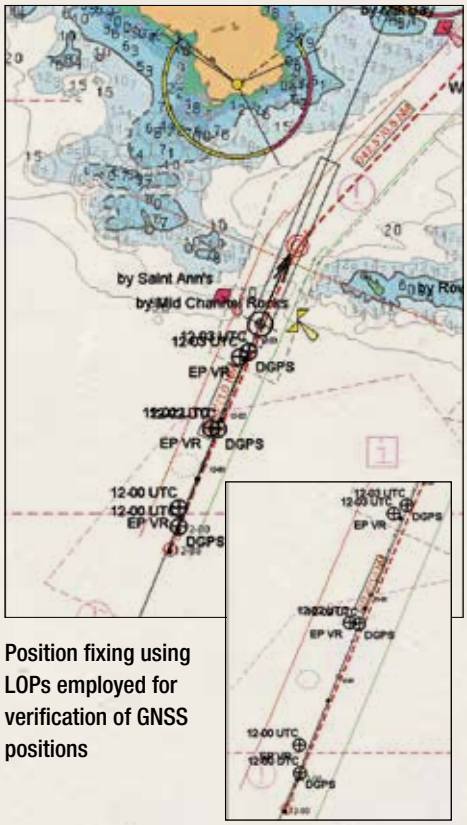
Using zero index line on ECDIS and radar for marking the reference for a wheel-over position for course alteration

The PI technique provides a reliable means of position monitoring in all states of visibility and also in case of failure or errors in input sensors.

PIs on ECDIS (rather than the radar) should only be used for route planning and information purposes. When monitoring the route, the prudent mariner will maintain, whenever possible in coastal and estuarial waters, a check on the integrity of the displayed position of their ship. When the source of the displayed position is own ship's (D)GNSS, there is always a possibility that the position displayed may not coincide with the ship's actual position. This can be checked quite easily by observing PIs on the radar display to monitor them by comparison with the planned track, comparing overlays on the ARPA and radar and monitoring the echo sounder where appropriate.

The lowdown on Lines of Position

A Line of Position is a line of observation where the ship position is expected to be located anywhere along that the line. On its own, a single LoP cannot provide a position fix, as the ship can be located at any point along the line. Navigators require at least two LoPs to plot a ship's position and should use a third LoP to verify the plotted position.

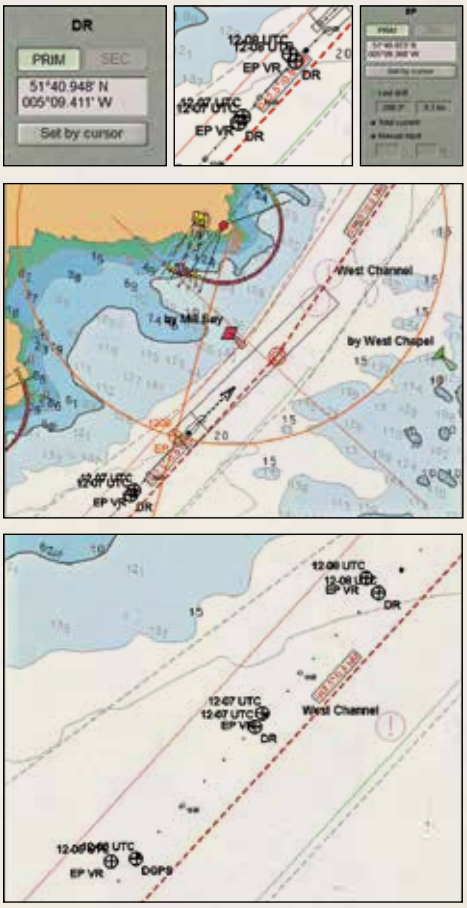


Position fixing using LOPs employed for verification of GNSS positions

Traditionally, navigators have used visual, radar and celestial LoPs to fix their ship's positions on paper charts. However, position fixing using LoPs has not lost its significance with the introduction of ECDIS, and manual position fixing has been a mandatory ECDIS function since 2009. The principle of using LoPs to fix ship position on ECDIS remains the same as on the paper chart, but with some added advantages:

- Manual position fixing on ECDIS is time dependent, and involves the application of running fix on LoPs, thus improving the accuracy
- Manual position fixing using LoPs provides a very reliable verification tool to cross-check the accuracy of GNSS position.

If the position sensor (GNSS) fails or develops a substantial error, the navigator is required to use Dead-Reckoning (DR) or Estimated Position (EP) as position input to ECDIS. Regular manual position fixing using LoPs improves the accuracy of both DR or EP methods as the positions are corrected with each fix. Some systems may require several steps to plot fixes to use with DR/EP mode, so it is important to be familiar with the process on the system on your own ship.



Position fixing using LOPs with DR or EP navigation on ECDIS

WATCH OUT

Do your layers line up?

'Fusing' information from other input onto the ECDIS or radar display using an Integrated Navigation System (INS) can greatly assist the Officer of the Watch (OOW) – but it can also seriously hinder the safety of navigation if not managed properly. Here, the UK P&I Club takes a look at how bad management can occur, what it means and how to avoid it

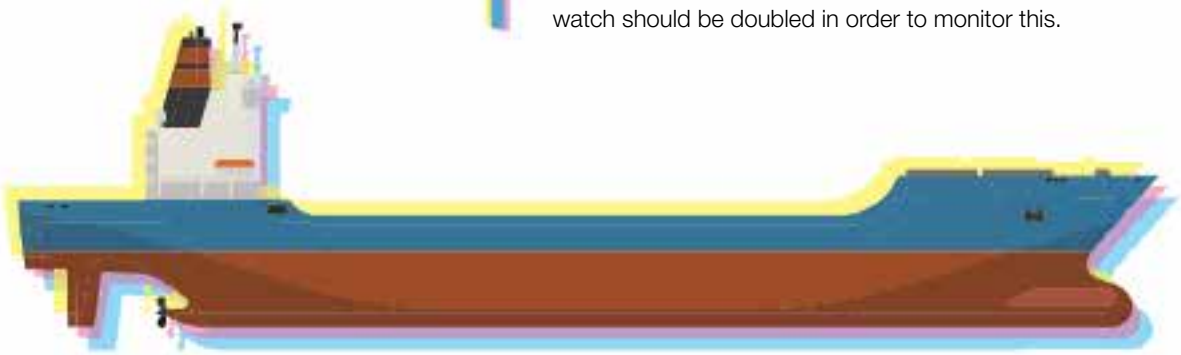
If layers of information projected onto the on board INS do not synchronise, this can result in serious navigational and collision avoidance errors, which the operator may not always notice.

Lack of synchronisation can be caused by various factors:

> Operator error due to not being properly familiar with the equipment provided
> GPS/GNSS accuracy in relation to the visual or radar fix accuracy
> Different speeds and courses from log input, as opposed to GPS track
> AIS target time delay in relation to the radar echo
> Lack of identification of radar targets

The loss prevention risk assessors of the UK P&I Club come across all of these errors at times. So how can they be avoided?

> It is very important that the OOW is totally familiar with the equipment in use, as well as the INS of the particular vessel, and has been trained and pre-qualified on that system.
> The system must be set to accurately reflect the track of the vessel at all times using speed over the ground and accurate position information. Avoid total reliance on GPS/GNSS. Use radar and visual fixes on ECDIS to ensure that the position of the vessel is properly monitored at all times.
> Radar layering should be accurately aligned to the Electronic Navigational Chart (ENC). Any layering slip may indicate that position accuracy has been compromised. Make sure this is monitored at all times, especially in confined waters and in pilotage. In these situations, monitoring by all available means is even more vital in our estimation.
> AIS and ARPA information layers must be used with caution. While AIS can give faster change of course and speed information, there are situations where linked target vectors can disassociate on screen. It is important to check all systems carefully and keep a good visual lookout. Never totally rely on the electronic information to be accurate.
> INS layers can be very useful – but there are times in confined waters where it may be more prudent to turn layering off on the ECDIS and use the ARPA and AIS information on separate systems instead. It is crucial to monitor all systems and use visual collision avoidance and visual fixing for additional safety. If possible, the navigational watch should be doubled in order to monitor this.



IT IS IMPORTANT TO CHECK ALL SYSTEMS CAREFULLY AND KEEP A GOOD VISUAL LOOKOUT

Always moving forward

Second Officer **Loid Anthony** talks about how coming from a family of seafarers inspired him to pursue his own maritime career, why good situational awareness is key to safe navigation and how sharing our knowledge can help the wider industry

What interests you about a career at sea?

Since I was a kid, I looked up to my uncles and cousins who enjoyed their lives at sea. Seeing them happy and satisfied made me decide to pursue the same career path. I was captivated by the idea and liked the benefits that a seafaring career offers. I love to travel and engage with different cultures and I admire the beauty of the sea. This is also a profession in which you need to be flexible to changes and brave enough to conquer the challenges ahead.

What career path has led you to your current role?

After graduating from high school, I was fortunate to be chosen for a scholarship to study marine transportation at university. This began to shape me into what I am now and helped to craft my skills and knowledge. The company I currently work for also has a career development monitoring programme that enables the crew to identify further areas for development. It has helped me discover the areas I need to learn more about and think about ways in which I can adjust my approach in order to improve. I have learned how to ask, persevere, adapt and always move forward.

Where do you see yourself in five years' time? Ten?

I see myself as someone who will still be passionate for my craft, as well as being more confident and more experienced. I want to be someone who provides support to the whole team efficiently and with a fair sense of responsibility. Eventually, in five years' time, I would like to take the Master's examination in my country and hopefully pass, and in ten years' time I would love to be in command of one of the bulk carriers running in the shipping industry. I am keen to play my part in creating a better environment for seafarers at sea with no boundaries or discrimination around culture or skin colour, where everyone can live fairly, express their insights freely and live and work on board ships without prejudice.

Name: Loid Anthony

Current Position: Second Officer

I WANT TO BE SOMEONE WHO PROVIDES SUPPORT TO THE WHOLE TEAM EFFICIENTLY AND WITH A FAIR SENSE OF RESPONSIBILITY

How do you keep your situational awareness skills fresh?

Situational awareness plays a vital part in our health and safety while we are at sea. The ability to be fully aware of what's happening around us is key. In order to cope with my duties and build a safer culture, I make sure I have enough time to rest, eliminate unnecessary thoughts through indoor and puzzle games, pursue meditation, follow a healthy diet and exercise, enjoy conversation with other crew members and keep in touch with my family. In this way, I keep my situational awareness skills sharp. Keeping myself comfortable and relaxed gives me the space to assess risk from different angles, make logical decisions, communicate well with the team and use all my senses to the best of my capabilities.

How much do you rely on technology when it comes to passage planning and navigation?

The rapid acceleration of technology over the last few decades has had a continuous impact on making our jobs a lot easier than before. I've been fascinated to see how new technologies are introduced. I like to spend time learning and understanding each piece of equipment on board ship. I find out about its limitations, strengths and weaknesses. Even as some of the more traditional navigational methods are slowly being phased out, I make sure to balance the use of new technology with the prevailing tools I have. Cross-checking multiple tools and equipment when doing passage planning and during navigation. It is so important to take in to consideration 'all available means', putting everything together and using my situational awareness skills to achieve the best results.

How has reading *The Navigator* helped you to carry out your duties at sea and to grow in your career?

Reading *The Navigator* has opened my eyes to more possibilities and opportunities for development. As an officer, it helps me to better understand our job and our life at sea. Reading about the different issues that are discussed helps me to assess my work and reminds me about what should be done to keep things on track. Through sharing knowledge like this, we build a better future for the industry.

Royal Institute of Navigation
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WAYPOINT

Dr Andy Norris FRIN FNI

Looking ahead

Dr Andy Norris, an active Fellow of The Nautical Institute and the Royal Institute of Navigation, highlights the advantages of electronic intelligence in navigational layering and data display, both now and into the future

The concept of navigational layers has been incorporated into ships' bridge display equipment for many years. IMO's first performance standards for ECDIS, adopted in 1995, covered layers in a section entitled "Display of Other Navigational information". It particularly highlighted the allowable overlay of radar data, provided the displayed ENC data remained visible.

Since then, there has been a steady increase in the electronic intelligence that can be incorporated into the layering, integration and display of navigational information to give navigators a better understanding of the situation around them. In 2007, IMO published its first Integrated Navigation System (INS) performance standards. This provided the base standards for such systems and has only needed minor revisions since then.

These standards have allowed ever-developing technology to steadily improve the presentation of the whole situation and to give better indications and/or warnings of discrepancies.

Inertial sensors

The variety of data that can be collected and sensibly displayed to improve the safety of navigation is increasing. Of great significance, inertial sensors are, at last, becoming affordable. These continuously measure the sensed movement of the vessel. Input from inertial sensors is used with knowledge from other systems of the vessel's position, bearing and speed at a given moment to provide automatic 'Dead Reckoning,' generating an estimate of the current position from the last known position.

The immense advantage of these sensors is that their basic measurements are unjammable and unspoofable. This means that a continuous overlay of the calculated position from such sensors onto an integrated display can give an excellent indication that normal positioning information, such as from GNSS, is becoming inaccurate. They continuously estimate the current position based on the best positional information available from other systems at 'n' minutes before. 'n', for example, could be ten minutes – depending on the actual accuracy of the fitted inertial sensor.

They not only provide a warning when a vessel's normal positional system is being compromised but also give a continued estimate of position – very important in such a situation. This is effectively based on the last uncompromised position, albeit with ever-decreasing accuracy. Military submarines have used inertial systems for many years, allowing long periods of totally underwater manoeuvring – but, in the past, at great expense.

Optical technology

Evolving optical technology can also provide overlays that make it much easier to correlate features from the current optical scene with the data on an INS display. A hand-held ePelorus, for example, instantly communicates the bearings of human-selected sights as an overlay on an integrated display.

Two or three sights on well-chosen charted and visual objects allow an independent position fix to be generated. These sensors make it so fast and easy to overlay visual bearings on the chart or radar display that it is possible to use regular, sensibly chosen single bearings to effectively maintain an independent check on the accuracy of the displayed scene. In reality today, the actual use of ePelorus remains low, despite their obvious and immense advantages.

The evolution of technology into the future will provide ever-greater insight into the current situation and the way it is depicted – and also highlight when there is any conflicting information. The active involvement of navigators in understanding the full scene is not at all diminished. Instead, these new developments allow navigators to give complete concentration to fully understanding the evolving situation, allowing the early detection and mitigation of potential problems.

THE EVOLUTION OF TECHNOLOGY INTO THE FUTURE WILL PROVIDE EVER-GREATER INTELLIGENCE INTO THE DEPICTION OF THE CURRENT SITUATION TO HUMAN NAVIGATORS

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TAKE 10

Navigational layers – and understanding how they work and what benefits they provide – are a crucial part of a navigator's role. Here are ten key points to add to your layers of knowledge:

1
Don't stand alone
Many navigation systems are designed to stand alone (ECDIS, radar, AIS, etc…) but are capable of being integrated.

2
Stronger together
Understanding how to manage integrated systems will help you improve your situational awareness and make better decisions.

3
Avoid overload
Poorly managed layers can lead to information overload and multiple symbols can mask critical information.

4
Fit for purpose
There is no one 'best way' to layer. Sometimes radar over ECDIS works well, other times a different set-up is better. Understand the differences and which combination to use.

5
Association is good
Some systems allow AIS and ARPA targets to be 'associated' into one symbol, giving strong support that the two different systems agree – disassociation tells a different story.

6
The more you know
Many systems, even those from the same manufacturer, have different control functions. Good familiarisation with your on board system will give you power.

7
Not just tradition
Plotting manual Lines of Position on ECDIS and using Parallel Indexing may seem like traditional skills from the paper age, but they are still valid and useful in the electronic age – understand why and how.

8
Into the future
In the future, many more 'layers' will be available, possibly from optical, satellite or sonar input. Watch out for these and understand how to use them to make good decisions.

9
All available means
Integrated Navigation Systems (INS) are a powerful tool when used correctly – but don't forget your other human tools of sight, hearing, feel, and the mariner's sixth sense.

10
Spread the knowledge
As more tools become available to the navigator we will all need to share this information to learn 'good practice'. Discuss these issues with your teams; mentoring isn't just senior to junior, but with this it may be junior to senior.

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