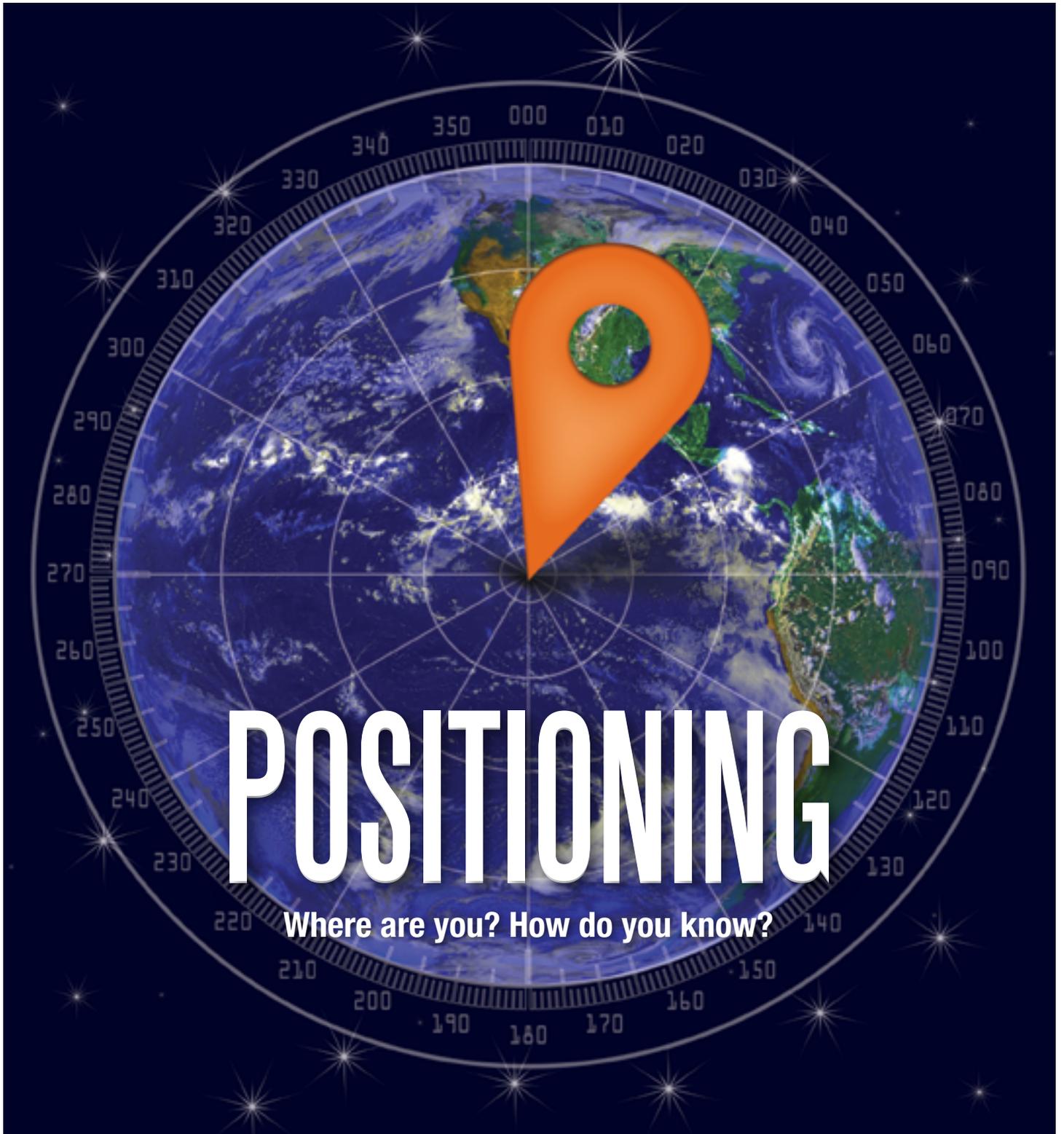


NAVIGATOR

THE

Inspiring professionalism in marine navigators



POSITIONING

Where are you? How do you know?



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



Maintain position

As a navigator, it is essential to know where you are in the world. Failure to do so could see the bottom ripped out of your ship and your whole day ruined! The modern navigator lives in interesting times when it comes to positioning. Some say that we are rapidly moving from an age of 'navigation as an art form' to that of 'navigation as a science'. However, it's probably more accurate to recognise that we are moving from an age where position fixing was a manual task, to one where positioning is mainly done automatically.

Regardless of how reliable GPS may seem, manual checks must be made on a regular basis. Few mariners have ever endured a sustained failure of GPS, and this leads to complacency. But we are continually reminded that GPS, as well as all other forms of Global Navigational

Satellite Systems (GNSS), such as GLONASS, Galileo, BeiDou, etc, are increasingly susceptible. These satellite systems all share a common vulnerability of relying on a relatively weak signal that can be disrupted by unintentional jamming, such as from solar activity; or from intentional jamming, such as people trying to mask the signal from their GPS tracked company cars.

Many other systems on a modern vessel also depend on GPS input. Failure of this signal will have quite a knock-on effect, so it is prudent to conduct a GPS loss drill on a routine basis, and perhaps incorporate this into the SMS.

The age-old adage for mariners has always been 'never rely on one source for positioning'. In the past, this has included not relying on range and bearing from a single object and never relying on

just two lines of position. Today, it might mean never relying on GNSS alone. The modern navigator must be competent and confident enough to use a number of positioning tools and techniques, including but not limited to visual bearings, radar information, depth soundings, celestial observations, dead reckoning, and – most importantly – visual situational awareness for checking plausibility.

We are in a transitional period where advancement in technology is charging ahead and sometimes the Human Element has difficulty keeping up. It is essential that modern navigators understand how to employ a range of positioning methods to assure them of where they are, particularly in relation to nearby navigational hazards. For example, with ECDIS navigators must be confident in the ability to plot visual and radar information, in order to ensure the integrity of positioning. This is essential as the navigator is responsible for many lives, the ship, the cargo and the environment.

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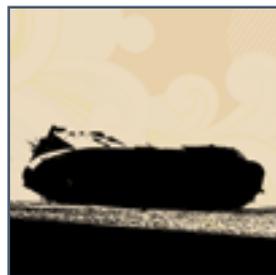
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The Navigator compares the strengths and weaknesses of various positioning methods.

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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 looked at passage planning at sea. Now, the crucial topic of positioning falls under the microscope, as we ask the seafaring community for their views on how to balance the use of traditional positioning techniques with more modern technology.

We are always interested in hearing your views on the important topics discussed in this publication. Contact the editor, [Emma Ward](#) at navigator@nautinst.org, or look out for the LinkedIn discussion at <http://www.linkedin.com/groups/Nautical-Institute-1107227>. The next issue looks at electronic charts.

Find The Navigator online at www.nautinst.org/thenavigator
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“ Any new and reliable technology should be welcomed. However we should learn from the medical profession, where stethoscopes and blood pressure monitors are still used. Knowledge of the basics is essential to form a foundation for a sound building. Let Rule 5 of the Colregs be the guide: keep a proper look out by sound and hearing, as well as by all available means. ”

Vinode Mohindra



“ Have you ever suffered a total bridge black-out? I did, during a trans-Atlantic voyage. Our first port of call had no means for repairs, hence we sailed for a month in the ‘old sailing ships way’. We used a magnetic compass, sextant, our beloved chronometer, land bearings and naked eye watch. We suffered no navigation problems or delays. I’ve never trusted blindly in electronics since. ”

Juan Manuel Lopes



“ I am very glad to see the stress put on safety. As a check on the GNSS, as well as a back-up for when the GPS might fail, I do feel that it is very important for a proper navigator still to be able to use a sextant and the necessary books to work out the sightings. ”

Rosalind Miranda



“ I enjoy being able to use a sextant, which is how I spent my early years of navigation, (and yes we carry two of them), but I think coastal navigation techniques are much more useful and relevant as a back-up for any potential failure of GPS / ECDIS / power supplies. ”

Hamish Elliott, AFNI



“ The basic principles of marine navigation should encourage us, whatever our age and experience, to explore any modern concept that links use of eyesight through a bridge window with automatic dead reckoning devices like ECDIS as an alternative positional source to GNSS. ”

John Ainger



“ A celestial observation eventually tells you where you *were*, but today’s technology instantly and constantly tells you where you *are*. That could be vital. ”

Reg Kelso



“ The most important thing is to be able to leave port A and arrive at port B safely and in the most economical manner. As a licensed trainer / assessor, to be on the safe side, I often tell my learners / candidates to keep the old and traditional methods of navigation in one hand and all modern navigational methods in the other - and to always sail with both hands. ”

Teorae Kabure

Reviewing the situation



Lack of situational awareness can leave you high and dry - as **Sam Pecota MNI** knows from experience.

Situational Awareness, or SA, has been succinctly defined as “Knowing where YOU are and knowing where THEY are.” “THEY” are, of course, other vessels. We avoid other vessels through proper application of the Colregs, employing manual or automatic radar plotting methods, or even more basically, simply looking out the window every once in a while.

All this takes experience and some skill. However, when considering the determination of ownship’s position today, the process could hardly be more basic. Global Navigational Satellite Systems (GNSS), such as GPS, and ECDIS (ECS) have made position fixing so simple, a five-year-old could figure it out. Mariners in today’s industry who think they can derive any sort of satisfaction merely from determining one’s position at sea are kidding themselves. GNSS/GPS is such a reliable

system that you could very nearly stake your life upon it anytime. Nearly so...

The trouble is, navigating has become so easy under normal circumstances, that loss of SA in more challenging, or exceptionally difficult conditions can become terrifyingly common.

Staying engaged

The necessity of remaining actively interested in the vessel’s position enough to do more than glance occasionally and absentmindedly at the ECDIS screen is a constant battle for today’s mariners. Because it is so easy, we become complacent. When our electronics fail, as they most assuredly will at some time, we must be able to recognise the failure immediately and react accordingly.

If one has not been correlating the ECDIS display with radar (ranges, bearings, parallel indexing) and visual bearings plotted on the ECDIS or paper chart, or even simply

looking casually at the scene passing by out the windows, a GNSS/GPS failure, even if discovered, can prove disastrous because the unfortunate mariner may not have time to recover from the loss of SA. The resulting grounding may produce anything from mild embarrassment to loss of career to loss of life and destruction of the environment.

A cautionary tale

The following example of loss of situational awareness is one I know intimately – it happened to me. As a young mate in March 1981, with four months seagoing experience, I ran a 100-metre hopper



**WHEN ELECTRONICS FAIL -
AS THEY WILL - WE MUST BE ABLE
TO REACT ACCORDINGLY**

dredger aground in a storm off Beaufort Inlet, North Carolina. This incident took place ten years before the widespread introduction of GPS, but it involved overreliance on a short range positioning system used in dredging known as Trisponder. Of similar accuracy to GPS, Trisponder lulled young mates like myself into a false sense of security, precisely because of its accuracy and ease of use compared with more conventional fixing methods.

I had my hands full trying to manoeuvre the unwieldy vessel close to a shoal at night in horrible weather. I took for granted the positioning information given by Trisponder and neglected to correlate that information with the picture on radar (admittedly messy in the rough waters) or even with visual navigational aids in the area. I fixated on the Mylar roll moving across the track plotter to the exclusion of anything else of navigational relevance.

When the vessel grounded so hard on the shoal that I had to perform a radical manoeuvre to get her free, it took the vessel beyond the area marked on the Trisponder chart roll. Because I had not familiarised myself sufficiently with the area surrounding our work assignment, either visually or on the paper chart, once out of that area, and



The grounded hopper dredger, similar to the one pictured left, made the nightly local TV news

without Trisponder help, I was lost. The vessel was soon firmly aground (at high tide, no less) and I was unable to work her off before the ebb tide. There we remained, high and dry until the next high tide.

We made the nightly local TV news, which showed embarrassing aerial shots of the stranded vessel under the caption “Large barge grounds on Shackleford Shoal.” [Hopper dredgers are often mistaken for barges.] There wasn’t any damage to the ship fortunately, but twelve hours of operational time were lost. My ego was bruised but I kept hold of my job.

There is an old adage that it is best to learn from the mistakes of others. I heartily agree, but I also submit that learning from one’s own errors, assuming they are not fatal to life or career, is nevertheless quite effective too. I never made the same type of mistake again in the thirty-some years since that miserable night in North Carolina.

Striking the right balance

For more than twenty years, GNSS/GPS systems have been serving mankind faithfully and efficiently in all kinds of navigational tasks. It would be absurd to admonish today’s mariners never to trust GNSS/GPS because of the very few instances where it can fail due to a variety of causes. Still, it is the wise mariner who utilises satellite navigation systems with the words of US President Ronald Reagan always in mind, “Trust but Verify.”

Cross-checking ECDIS or ECS positions with other navigational data not totally dependent on GNSS/GPS may be tedious, but is also vital for marine navigators to remain alert and ready to handle any primary navigation system failure. Maintaining an acceptable level of situational awareness depends on the frequent comparison of multiple position fixing sources as a matter of routine. And a routine situation is infinitely preferable to an emergency.

Positions, please



The Navigator examines the different positioning methods out there and asks what benefits each of them have to offer – and what pitfalls need to be avoided

Positioning is essential for navigation: to ensure you have situational awareness; know where you are in relation to navigational hazards and, of course, to enable effective commercial operations. At this time, there is no one perfect means of fixing your position. A wide range of options exists,

and professional mariners must know when to use each, based on their strengths and weaknesses. Of course, the professional navigator will always employ as many means as possible and will never rely on any one alone. Knowing which methods to use when is key to success as a navigator



Dead Reckoning and Estimated Position

Dead reckoning (DR) is predicting where you will be, based upon speed and course. An 'estimated position' (EP) refines that prediction further by applying set and drift. Estimating where you should be at what time was essential in the past, but still very useful in modern times for aiding situational awareness and giving advanced warning of any anomalies in other means of positioning.

Strengths

- > Proven traditional technique
- > 'Automated' systems embedded within ECDIS
- > Uses existing sensors - log, gyrocompass, etc.
- > Potentially gives rapid alerts of loss of GNSS accuracy
- > Reasonable accuracy over shorter periods

Weaknesses

- > Currently, poor accuracy over long periods
- > Some ECDIS equipment have poor embedded implementations of DR/EP



Visual Observations

Visual observations are an excellent way of maintaining situational awareness. This can entail everything from plotting compass bearings, following leading lights, to the noting of beam bearings.

Strengths:

- > Excellent for maintaining situational awareness
- > Leading lights and sector lights are valuable in pilotage areas
- > Should be used in conjunction with ECDIS and radar for checking and back-up
- > Helps when interpreting a radar picture

Weaknesses:

- > Reliant on good visibility
- > Must be within visual range
- > Object of bearing must be clearly identified

Celestial

Celestial navigation remains a valid means of positioning and an excellent back-up to GNSS and compass checking, particularly when offshore.

Strengths:

- > Sole (universally available) back-up for GNSS and compass checking off-shore
- > Capable of very good accuracy, 1 NM or better is possible from dawn and dusk star fixes
- > Not reliant on electronic systems

Weaknesses:

- > Needs clear sight of celestial bodies and horizon
- > Can be difficult to accomplish in heavy weather
 - > Competency for use relies on regular practice
 - > Not suitable for inshore navigation – not a “real time” method
 - > Needs up-to-date data (paper or electronic) for processing

Other Systems

Echo Sounder: Excellent complementary tool to confirm when you come across anticipated depth areas, but can rarely give an independent position. Vessel can follow a depth contour as a crude form of indexing.

Loran and eLoran: Terrestrial electronic positioning systems that are much more resilient against intentional jamming, interference or spoofing than GNSS. Although Loran has been largely decommissioned, its potential successor, eLoran, is currently being explored by a number of countries, including India and the UK, as a valuable back-up to GNSS.

Multi service or integrated receivers: A device being developed to accept input from all forms of GNSS, eLoran and other yet-to-be-developed systems. Currently integrated GPS/GLONASS/SBAS systems are available and more comprehensive systems will follow in time.

Inertial Navigation Systems: Use accelerometers and gyros to measure the movement of the ship and provide position by an automatic assessment of EP. These systems are used to good effect in military applications, but are currently very expensive and so not cost-beneficial for commercial merchant service.

Specialist close-in systems: Operations such as Dynamic Positioning require multiple independent automated navigation systems, although these are only useful over short ranges and for vessels with the specialist equipment. These systems can include taut wire, acoustic transponders, fanbeam, etc.

Radar

The use of radar is time-tested for positioning and can be highly accurate. It is fully independent of external sources. Radar is highly effective when using parallel indexing, and can supplement GNSS particularly when overlaid on ECDIS.

Strengths:

- > Self-contained positioning system, can be set to require no external support
- > Racons provide clearly identified important objects and aids to navigation
- > Radar and target tracking functionality (ARPA/AIS) provide a range of effective tools and alarms to support decision making, e.g. target notification, CPA notification
- > Improves situational awareness in restricted visibility

Weaknesses:

- > Objects must be within radar visibility
- > Subject to interference from heavy seas and weather
- > Reliant in some modes on accurate gyro input
- > At times a Radar picture can be difficult to interpret

Global Navigational Satellite Systems

GNSS, and more specifically GPS, have been rapidly integrated into modern navigation and can be particularly effective when integrated with ECDIS. These systems give real-time global coverage and historically, have been highly reliable.

Strengths:

- > Generally very accurate and reliable position fixes
- > Global coverage with 24/7 availability
- > Increased accuracy and reliability when used with differential systems, including Satellite Based Augmentation Systems (SBAS)
- > Easily integrated into a wide range of onboard systems
- > Position can be clearly displayed on ECDIS

Weaknesses:

- > Easily susceptible to intentional or non-intentional jamming or spoofing
- > Complacency from ease of use can lead to over reliance on a single system

! WATCHOUT

Never is the navigating officer more crucial than in ensuring the safety of a ship and its crew at sea. Responsible primarily for human lives, they also safeguard valuable cargo, plus the ship itself and environmental safety. In this series, we take a look at maritime accident reports and the lessons that can be learned

Complacency and distraction lead to grounding

The Scenario

A container vessel ran aground on a bank in the early hours of a winter's morning. Her second officer had stood the lookout down and relied on the electronic chart system to navigate. He became distracted by his mobile phone and failed to carry out a planned course alteration, leading to the grounding. Although the Master was able to refloat the ship, the second officer's lack of engagement in positioning caused easily avoidable damage and delay.

What happened?

The second officer was in charge of the bridge. He judged the weather conditions to be good and shipping traffic to be minimal with plenty of time before the course alteration needed to happen. Although all the information on the ship's position was available to him, he did not make use of it.

Why did it happen?

The second officer was in charge of the bridge at the time of the grounding and had reported good conditions at sea, with few other vessels in the vicinity. About an hour before the ship ran aground, the lookout had been sent to stand-by in the crew mess as a result of the clement weather and lack of shipping traffic. He had taken this instruction to mean that he could go and get some sleep.

Meanwhile, the second officer had become distracted by the VHF and was texting prolifically on his mobile phone. He checked the ship's position only once when walking past the electronic chart display and did not cross-check it at all on either the paper charts or any other onboard positioning equipment. It is thought that the second officer's text messaging activities distracted him further, so that the planned course alteration was missed, leading to the grounding about half an hour later. He only realised his error when he felt the ship's vibrations a short while later.

The Master was alerted, and managed to refloat the ship after an hour by pumping out ballast and using the bow and stern thrusters, plus the main propulsion. A subsequent diver survey revealed two breaches of the hull into water ballast tanks, so the vessel was released to sail to her destination for temporary repairs.

It was concluded afterwards that the OOW had relied too much on the electronic charting system for positioning, and that the equipment had only been used in a basic capacity. No cross-tracking, no-depth, no-go or waypoint alarms were set on the system. Neither did the paper charts have regular positions marked, although they were the primary means of onboard navigation. Fixes were recorded in the log, but these were only derived from the GPS by the second officer, despite navigational best practice stating that positions always be cross-checked with independent sources.

What changes have been made?

A recommendation was made to the ship's managers to review her ISM system to address navigational practice, electronic chart systems training and the use of mobile phones while at sea. Positioning procedures have been re-evaluated and officers reminded about the importance of remaining alert and avoiding becoming distracted while on duty on the bridge.



Shaping dreams into reality; making the most of life at sea

In this series, *The Navigator* speaks to current navigational personnel about their motivations, careers to date and thoughts for the future. Under the spotlight this issue is Company Cadet Training Officer, **Eldine Chilembo**.

What interested you in a career at sea?

My country, Angola, has a booming oil industry but not much of a maritime culture. At first, I hoped to break down the barriers that prevented women from moving forward in a male-dominated industry. Then I realised just how much I enjoyed the maritime industry.

What is the most enjoyable part of your working life?

Although my career is shore-based, I spend a lot of time on vessels, monitoring the progress of cadets. I love interacting with the crew. There is so much diversity and so many opportunities to exchange experience and techniques.

What do you enjoy most about working with cadets?

Having been a cadet myself not so long ago, I understand the struggles and

challenges they might be facing as they try to shape their dreams into reality. It's also very fulfilling, especially when I visit a vessel to check on the progress of a cadet and get good reviews from the Captain and crew. It's nice to see them determined to get to the top.

What are the most important points for young cadets/navigators to remember?

Discipline is always at the top of my list. Life at sea has its social, physical and mental challenges and cadets who are just starting off have a lot to deal with. They need to get used to being away from

home for long periods, being isolated and learning to understand different characters. This can only be made easy by staying focused on what they wish to achieve.

How has membership of *The Nautical Institute* helped you in your career?

I get great advice from a lot of the experienced minds out there. I have an opportunity to interact with people who are just as dedicated to the work they do, and to solving the problems we face as practicing and non-practicing mariners. I especially enjoy the discussions taking place in the NI groups on the various social websites.

Have you ever experienced mentoring at sea, or been a mentor? How important is this to the future of the industry and why?

I have had the privilege of being mentored by great and experienced captains, right from the time I joined the industry. They encouraged and advised me. They saw the potential in me to succeed and helped nurture it. Every cadet needs to find a person in the industry whom they wish to emulate, and grow under their guidance.

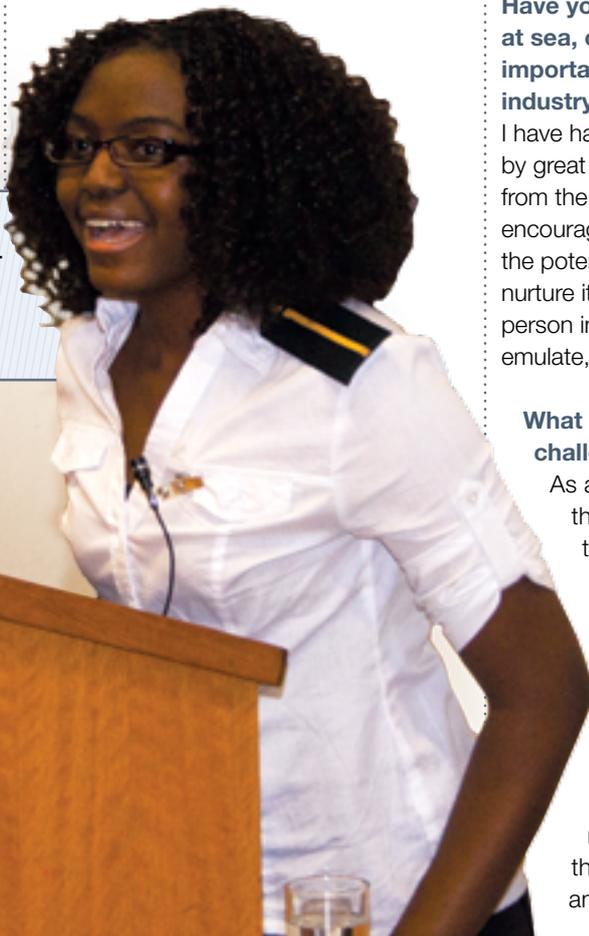
What do you think are the greatest challenges for future navigators?

As a training officer, it worries me that very little time is spent training the new additions to the industry. It is a challenge to encourage some officers to take a cadet under their wing. Not only is it an obligation for masters to train, it also ensures that experience is passed down to young minds. With less time devoted to training, more and more officers are graduating into the industry with less experience and know-how.

Name: Eldine Chilembo AMNI

Current position: Company Cadet Training Officer

Training: S3 and S4 for Mates and Masters, Cape University of Technology, South Africa





WAYPOINT

Dr Andy Norris FNI FRIN

How do you solve a problem like positioning?

Dr Andy Norris, an active Fellow of *The Nautical Institute* and the *Royal Institute of Navigation*, asks why positioning is still such a problem to the modern navigator.

The introduction of a full GPS service in the 1990s seemed to suggest that global navigation satellite systems (GNSS) were the final answer to a vessel's navigational needs. This standpoint was accentuated when President Clinton announced in 2000 that the artificial degradation of accuracy known as Selective Availability would be immediately removed. This improved GPS accuracy for non-defence users from 100 to more like 10 metres.

Users had seen full coverage of GPS steadily emerge, and soon realised that the most probable error that they would encounter would be a local failure with the vessel's GPS receiver. This led to two or more receivers being fitted to most vessels, making the total loss of position a very rare event. Early GNSS-related accidents, not least that of the *Royal Majesty*, also led to improved alert standards for new equipment.

Radio interference

The availability of differential GPS (DGPS) in many coastal regions further increased positional accuracy and integrity – and the reliance on GPS. Underneath, a few problems were emerging. For instance, in some areas it had become evident that local TV stations were causing interference to many receivers; electronic failures in other radio equipment could occasionally cause massive interference; some naval radars were capable of blanking out GNSS over a wide area.

In fact, these problems were not being encountered by most users, perhaps leading many into undue complacency about the continuing availability and accuracy of GPS. Even the widely publicised fears about jamming and other

potential problems have, to date, been rarely seen at sea.

In world politics terms, the lack of any significant incidents has perhaps also meant that the potential issues have failed to get any immediate resolution. In the past 10 years, governments have mainly acted to reduce the reliance on the sole use of GPS by setting up alternative satellite-based systems.

Unjammable technology

GLONASS has become a good, publicly available GNSS and other systems are planned to become global too, such as Galileo and BeiDou. This all contributes to improved integrity. Unfortunately, they all work on similar frequencies with

OOWS MUST BE EXPERTS ON THE POTENTIAL PROBLEMS WITH GNSS AND HOW SUCH PROBLEMS CAN BE QUICKLY IDENTIFIED. NOT LEAST, THE KNOWLEDGE AND SKILLS OF HOW TO SAFELY NAVIGATE WITHOUT GNSS MUST BE MAINTAINED AND UPDATED

similar signals, which makes them equally susceptible to jamming and interference.

Unfortunately, the military – traditionally the monetary sponsors of positioning systems – are generally not interested in systems such as eLoran, because all radio frequency based systems are jammable; at least by an opposing military force. Instead, they have an ever-growing interest in inertial-based positioning systems, which are effectively unjammable. There is a lot of research taking place into

making such systems more accurate, smaller, and less expensive. One day, the maritime industry will undoubtedly benefit from such technology.

Good seamanship

eLoran is a proven technical solution for merchant vessels, but its effective implementation over wide areas needs relatively complex coordination by multiple countries. High power transmitting ground stations with very tall antennas are required, typically spaced at about 1,000 kilometres. Also, to match the accuracy of GPS, local differential stations are needed close to ports and other critical areas. This all requires good inter-government resolve, interaction and funding.

As pointed out throughout this edition of *The Navigator*, the potential for major problems on the over-reliance on GNSS is real and growing. However, because of the complexity of getting agreement for

secondary systems, it could be many years before good solutions for vessels are both available and globally effective.

In the meantime, we have to rely on good seamanship. OOWs must be experts on the potential problems with GNSS and how such problems can be quickly identified. Not least, the knowledge and skills of how to safely navigate without GNSS must be maintained and updated – as has effectively been the case since the earliest days of navigation.

TAKE AWAY 10

This issue of *The Navigator* has looked at positioning at sea. Here are ten points to take away from this issue to help ensure this important subject stays top of everyone's list of priorities.

1

Aware and alert

Professional navigators need constant situational awareness to ensure the safety of lives, the vessel, her cargo, the environment and to ensure commercial effectiveness.

2

Safety in numbers

Never rely on a single means of fixing the ship's position.

3

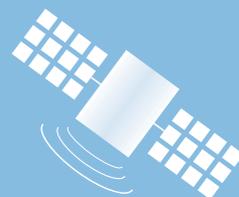
Check, check and check again

Good situational awareness requires the continual checking of complementary positioning systems and the intelligent application of common sense.

4

Judging the jamming risk

Although the coordinated use of multiple GNSS, such as GPS and GLONASS, improves reliability, all GNSS share a common weakness and therefore are equally susceptible to intentional or unintentional jamming.



5

Multiple choice

There are many methods of positioning available for the navigator, some based on traditional techniques and others on modern technology. Each has strengths and weakness and no one system has proven to be good enough to use on its own.

6

The Human Element

Although all these positioning methods may be complementary, they are not always automatically integrated. The professional mariner needs to be the human integrator of these systems and this skill require training and practice.

7

Prepare for failure

The loss of GPS is a real risk, and should be identified as such, with clear procedures for identifying failure, contingency plans and drills for dealing with the loss.

8

Avoiding over-reliance

Over-reliance on GPS, particularly when integrated into ECDIS, can lead to complacency and poor decisions. The use of GPS with ECDIS has revolutionised navigation and all shipping companies and crews should assess how this impacts on navigational practices.

9

Pole positioning

Training for the use of electronic positioning systems should not just address how to use the knobs and buttons ('knobology'), but most importantly, how to use technology to support good decisions with full awareness of inherent weaknesses.

10

Share your knowledge!

Mentoring is key. Experienced mariners should take time to help fellow mariners master positioning techniques. This may be Masters mentoring in the use of the sextant, or juniors helping the older generation understand the application of technology.



Available now from The Nautical Institute

The Nautical Institute produces a range of publications aimed at enhancing the standing and knowledge of maritime professionals, with discounts available for Institute members and bulk orders!



RADAR and AIS – Dr Andy Norris FNI FRIN

From 2008 all new radars were required to display AIS information, and this book looks at the implications of integrating these functions. It explains how radar and AIS systems can be better integrated with overlay and underlay displays, to assist with decision making on board.

Published: **2008** Price: **£30** Ref: **0307**

ECDIS and Positioning – Dr Andy Norris FNI FRIN

Written especially for mariners, this book will help improve your understanding and approach to the use of electronic charts, and provide guidance on how to develop the mindset needed to use ECDIS safely and effectively.

Published: **2010** Price: **£40** Ref: **0321**



Astro Navigation – The Admiralty Manual of Navigation Vol 2 – Lt Cdr Alan Peacock

STCW demands that seafarers are able to use celestial navigation as backup. This practical working guide to the art and science of celestial navigation is an essential volume, covering mechanical skills and calculation methods.

Published: **2011** Price: **£60** Ref: **0328**

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