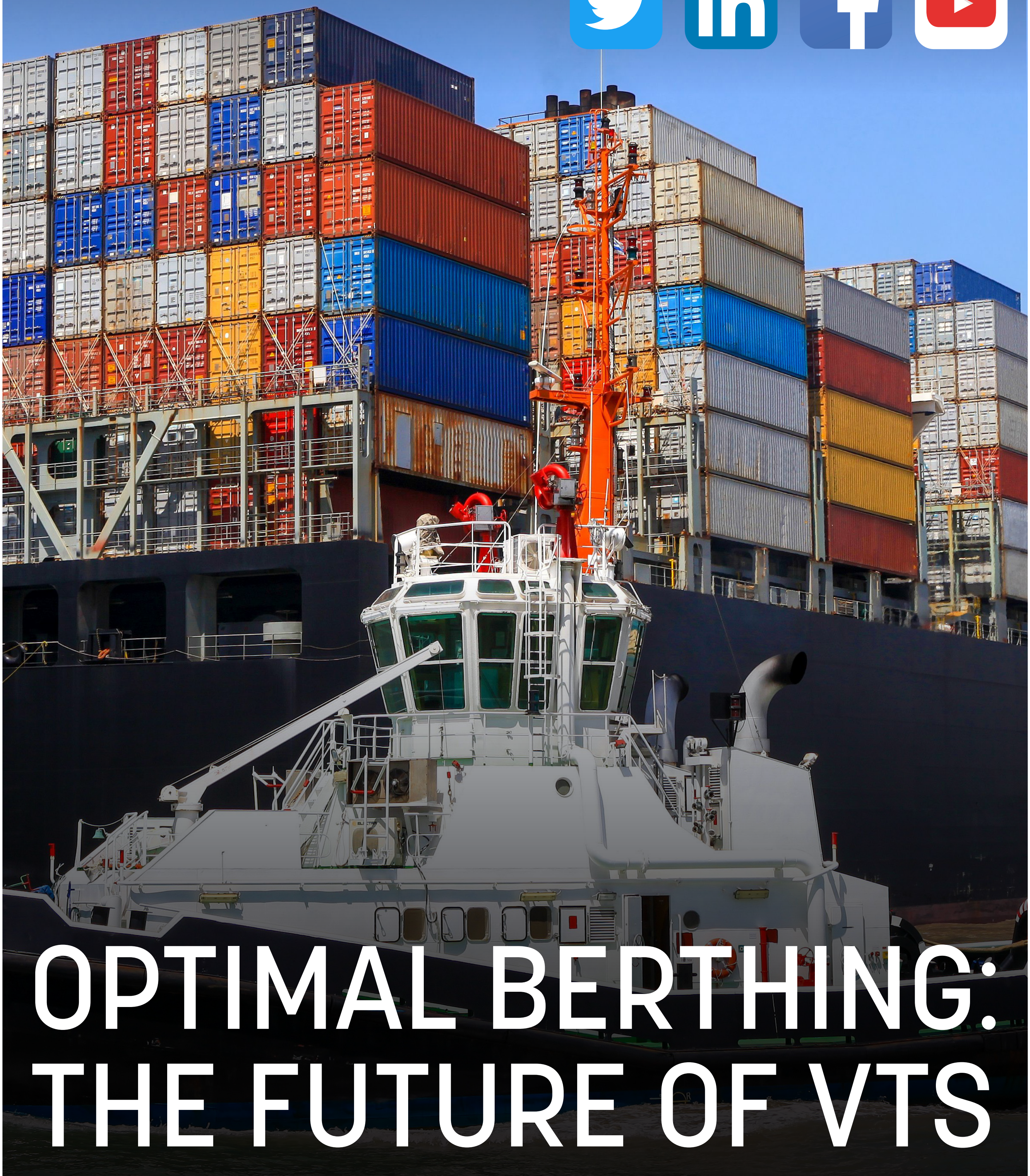
PORT TECHNOLOGY
EDITION 88 - 2019

# THE E-JOURNAL OF PORTS AND TERMINALS



# OPTIMAL BERTHING: THE FUTURE OF VTS

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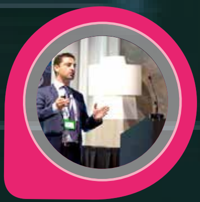

## C-LEVEL PANEL: SMART DIGITAL PORTS OF THE FUTURE

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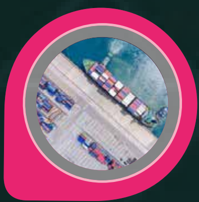
## THE REAL VALUE OF SMART DATA

Confirmed panellists include: Algeciras Port Authority and Drewry Associates



## EMERGING PORT TECHNOLOGIES: PORT DIGITALIZATION & INNOVATION

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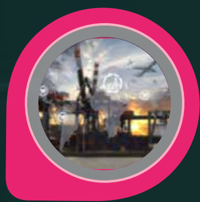

## INTELLIGENT TRANSPORT SOLUTIONS & TECHNOLOGIES

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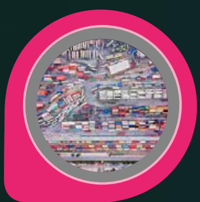

## END-TO-END DATA INTEGRATION & STANDARDIZATION

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Ivano Di Santo, CIO, Trieste Port Authority

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FROM THE

# EDITOR

Among the many technologies being pursued by the ports and terminals industry, those in the area(s) of vessel traffic services (VTS), mooring and berthing are among the most important.

Despite macro-related fears, global trade continues to boom and this means ever increasing pressure on ports and terminals.

As part of this rapid growth has seen carriers, operators and stakeholders explore the commercial viability of new shipping routes, such as the Northern Sea Route (NSR), which has itself raised questions over safety and the vessel tracking in areas as remote as the Arctic.

One solution that could make the Arctic safer and unlock its potential is satellite technology and this is the subject of Dr Meyer-Larsen, Project Manager, Institute of Shipping Economics and Logistics (ISL).

In his paper, Dr Meyer-Larsen explores the potential of satellites in maritime operations with a specific focus on their ability to increase efficiency and safety standards.

Also featured in this paper is Richard Hepworth President, Marine and Infrastructure at industry specialists Trelleborg.

In his paper 'Authenticating Fender Performance', Hepworth has detailed importance of effective and reliable fender systems and how overall performance is affected by a number of key factors, including velocity and temperature.

Furthermore, this edition also includes a technical paper from Commodore Barry Goldman, Representative of the International Harbour Masters' Association, who has written about the VTS tech revolution and the maritime industry has and continue to innovate.

Anders Johannesson, Swedish Maritime Association, and Katie Aylward, PhD student, University of Gothenburg, has also offered a brilliant insight into the importance of VTS, and in doing so looked at its key objectives: efficiency, safety and protecting the environment.

There is also a paper from maritime and port and engineering specialists SiPort21 on the subject of bollards in terminals, with a specific focus design and how ports and terminals are managing the traffic of larger ships.

Much has been written about the rate at which ports are expanding and the technologies that will accompany them in the future. This edition continues that conversation and looks at issues and ideas around how to make the movement of vessels easier, safer and more environmentally friendly.

I hope you enjoy this edition.

Max Schwerdtfeger
Editor

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# CONTENTS




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# AUTHENTICATING FENDER PERFORMANCE

Richard Hepworth, President, Trelleborg's marine and infrastructure operation, UAE

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Effective and reliable fender systems are mission critical equipment. However, not all fenders are created equal. Rubber compounds are changing and new manufacturing bases are emerging. Testing procedures need to keep pace to ensure fender performance standards are maintained. Regulations and guidelines exist, but how can you be sure that the product you buy is genuine? Is the test certificate enough to guarantee performance? Can you really trust catalog claims?

This article seeks to highlight the key steps to authenticating fenders to help designers, operators and owners of port infrastructure procure these systems confidently, safe in the knowledge that they are investing cost-effectively in equipment that guarantees quality and reliable performance over the long-term.

## BERTHING VELOCITY AND TEMPERATURE

### VELOCITY FACTOR

Velocity testing is critical to understanding how a fender will perform once in situ. While it's impossible to replicate the actual berthing velocity of vessels in testing, which is normally anywhere between 20mm/sec and 500 mm/sec, it is possible to carry out rigorous testing that simulates these berthing conditions.

The type of raw rubber used in compound formulation significantly influences velocity factor (VF). Testing shows VF is highly dependent on the blend and ratio of natural rubber (NR) and synthetic based rubber (SBR) used in the overall rubber compound formulation. Fender manufacturers should always provide commentary in relation to the application of VF in their rubber compounds and fender designs. By performing this kind of research and making the data available, fender suppliers and manufacturers can increase understanding and improve standards across the industry.

Robust chemical and physical material testing is also required to ensure that reclaimed rubber and non-reinforcing fillers are not used in fender production. These substitutions may not always be declared in supplier documentation, but will negatively impact the fender's ability to absorb the designated berthing energy of a vessel and therefore protect berthing vessels and port infrastructure.

### TEMPERATURE FACTOR

Temperature factor (TF) is vital in understanding changes to reaction force and energy absorption of fenders in normal operating conditions. This is because the stiffness (modulus) of the rubber compound changes dramatically with temperature which, in turn, impacts how the fender performs in situ. Ideally, rubber elements for fender systems should be tested on a case-by-case basis in accordance with the temperatures they will be subjected to in the field.

Similar to VF, TF is highly sensitive to the type of rubber used – NR or SBR, or a blend of the two, as well as the inclusion of recycled rubber. TF therefore varies with fender type and from manufacturer to manufacturer, meaning test results are unique to each individual fender. Care should be taken when comparing products from different manufacturers, as factors will differ depending on the type of rubber compound used during production. This is not always taken into consideration by manufacturers and suppliers due to a lack of testing data for their compounds.

## ANGLE

Differing port infrastructures and vessel sizes mean that the angle of berthing will vary depending on circumstances. A fender system must be designed to have enough energy absorption capacity to accommodate the appropriate berthing patterns.

### ANGLE FACTOR

Fender performance will vary depending on the angle of contact that results from a vessel's berthing approach. Therefore the capacity requirements in a fender system designed to accommodate parallel berthing will differ significantly from one with an acute angle of approach. Understanding how well a fender is able to absorb energy at different angles is critical to its performance at the quayside.

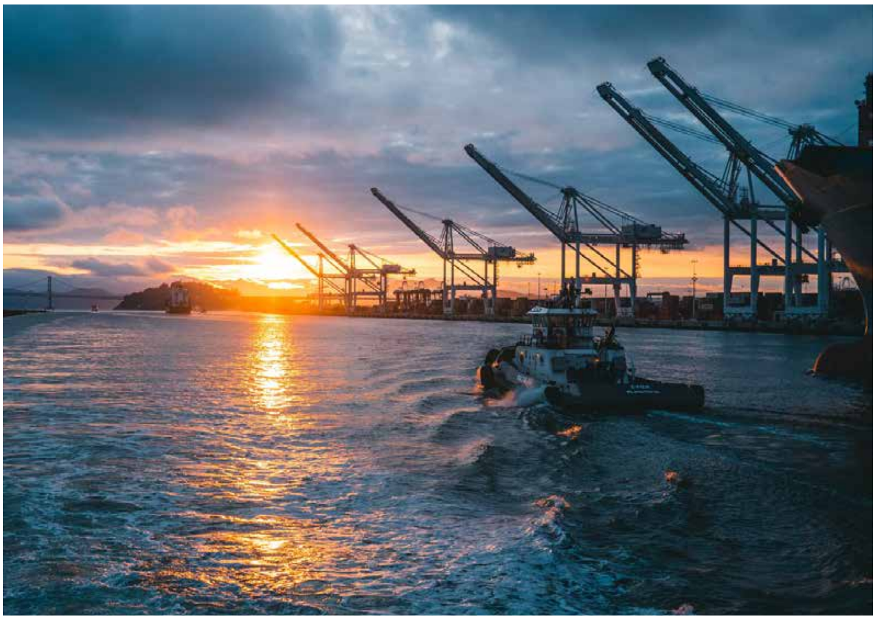
For fenders to meet Active Standard ASTM F2192 and PIANC 2002 guidelines requirements, rated performance data (RPD) must include the testing of fenders at zero degree angle of approach. By zeroing in on the angle factor, this should allow for easier comparison of fender performance data using other testing parameters (temperature, velocity, deflection). However, this is just the first step. In addition, manufacturers must also provide adjustment factor information for contact angles at 3, 5, 8, 10, 15 and 20 degrees – for each fender type. This makes it possible to determine if there is a reduction in performance (energy absorption) at larger berthing angles.

Manufacturers should clearly indicate in their RPD if chain restraints are factored in, as this will impact results data. Similarly, manufacturers should show angle factor testing data in relation to both transverse and longitudinal angular berthing to illustrate performance under different berthing conditions.

## INDEPENDENT TESTING

Performance verification testing is usually performed in a large press or test frame with either load cells or pressure transducers. Outside of manufacturers' facilities, these test frames are extremely rare. As a result, performance testing usually occurs in manufacturers' own factories, meaning results are sometimes not fully objective.

During testing, it is not uncommon for fenders to be specifically selected for the test rather than chosen at random.



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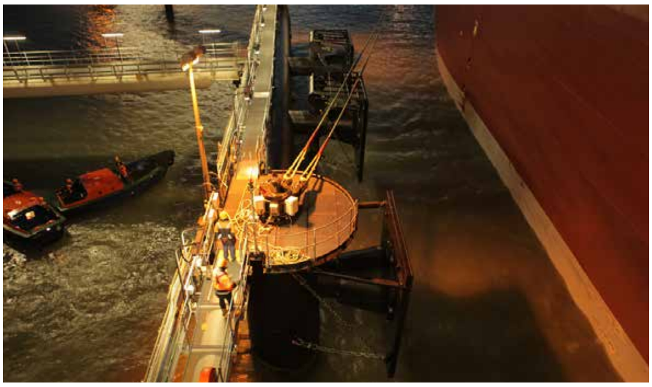

These fenders could be built to pass performance tests, but when it comes to creating the products that actually go to market, some manufacturers may use low cost, substandard materials in production. Similarly, some unethical manufacturers may also simply manipulate test results before going on to build and sell low quality fenders which aren't fit for purpose.

The industry's response to this has been to introduce independent witnessing to verify the authenticity of results. However, the implementation of this process has also been flawed.

## UNRELIABLE WITNESSES

Common practice in the industry has relied on factory testing with witnessing by either a third party or a consultant. However, there is no easy way for witnesses to verify the results independently of what the manufacturer is reporting. Modern data acquisition methods rely on computers to interpret the data and produce a report. The witness rarely has any understanding of how the data acquisition system functions, making it easy for unscrupulous manufacturers to manipulate the recorded data in the computer without the witness knowing.

Many project specifications require a third party inspection agency to witness the test. The shortcoming here is that witnesses do not provide oversight on how the test data was acquired or if the report they are asked to endorse is even from the test they observed. The inspection agencies are not necessarily guaranteeing the validity of the data they are endorsing - essentially potentially rendering their endorsement useless.

## TRUE INDEPENDENT TESTING

The fender industry involves big contracts and vast sums of money and there is too much at stake to allow manufacturers to serve as their own regulators. Our industry must move towards true independent testing, rather than just witnessed testing, and the simplest way to get objective, trustworthy results is to conduct tests in an independent laboratory.

The long term goal for the industry is for manufacturers to have testing at their own facilities but with independently recorded results. This will remove any uncertainty from the results and enable end users to have confidence that the lifecycle and performance of fenders meet specification, and that fenders are therefore fit for purpose.

## CONCLUDING THOUGHTS

Fenders have a direct impact on the safe and efficient operation of our ports, helping improve berthing management procedures and increase vessel throughput. Therefore it is vital that the industry works towards a deeper understanding of the impact of VF, TF, angle of berthing and independent testing on fender performance. This will ensure designers, operators and owners of port infrastructure invest in equipment that guarantees quality and reliable performance over the long-term.

For further press information please contact Chris Sanders at Stein IAS, Clarence Mill, Clarence Road, Bollington, SK10 5JZ, United Kingdom. Tel: + 44 (0) 1625 578 578; Email: chris.sanders@steinias.com

Notes to Editors: Trelleborg's marine and infrastructure operation and Trelleborg Group

The marine and infrastructure operation of the Trelleborg Offshore & Construction business area, is a provider of engineered polymer solutions to the marine, infrastructure and renewable energy industries. It manufactures and installs bespoke fender systems, docking and mooring equipment, oil and gas transfer technology and vessel efficiency technology for marine environments all over the world. Its polymer engineering expertise also extends to its range of general marine products, including navigation aids and buoys. Performing in some of the harshest environments on earth, its principal infrastructure and energy offerings are sealing systems for tunnels, dredging hoses, water management solutions, building vibration isolation, and polymer seals for offshore applications.

https://www.trelleborg.com/en/marine-and-infrastructure

Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has annual sales of about SEK 34 billion (EUR 3.32 billion, USD 3.92 billion) in about 50 countries. The Group comprises five business areas: Trelleborg Coated Systems, Trelleborg Industrial Solutions, Trelleborg Offshore & Construction, Trelleborg Sealing Solutions and Trelleborg Wheel Systems. The Trelleborg share has been listed on the Stock Exchange since 1964 and is listed on Nasdaq Stockholm, Large Cap. www.trelleborg.com.


## ABOUT THE AUTHOR

Richard Hepworth is a Chartered Mechanical Engineer, having studied for his degree at the University of Manchester Institute of Science and Technology and now holds the position of Business Unit President for Trelleborg's marine and infrastructure operation, based in Dubai. Richard has over 20 years' experience working in the offshore and marine construction industry.

## ABOUT THE ORGANIZATION

Trelleborg's marine and infrastructure operation is a global provider of highly-engineered polymer solutions for the advancement of operational performance across the marine, infrastructure and renewable energy industries.

## ENQUIRIES

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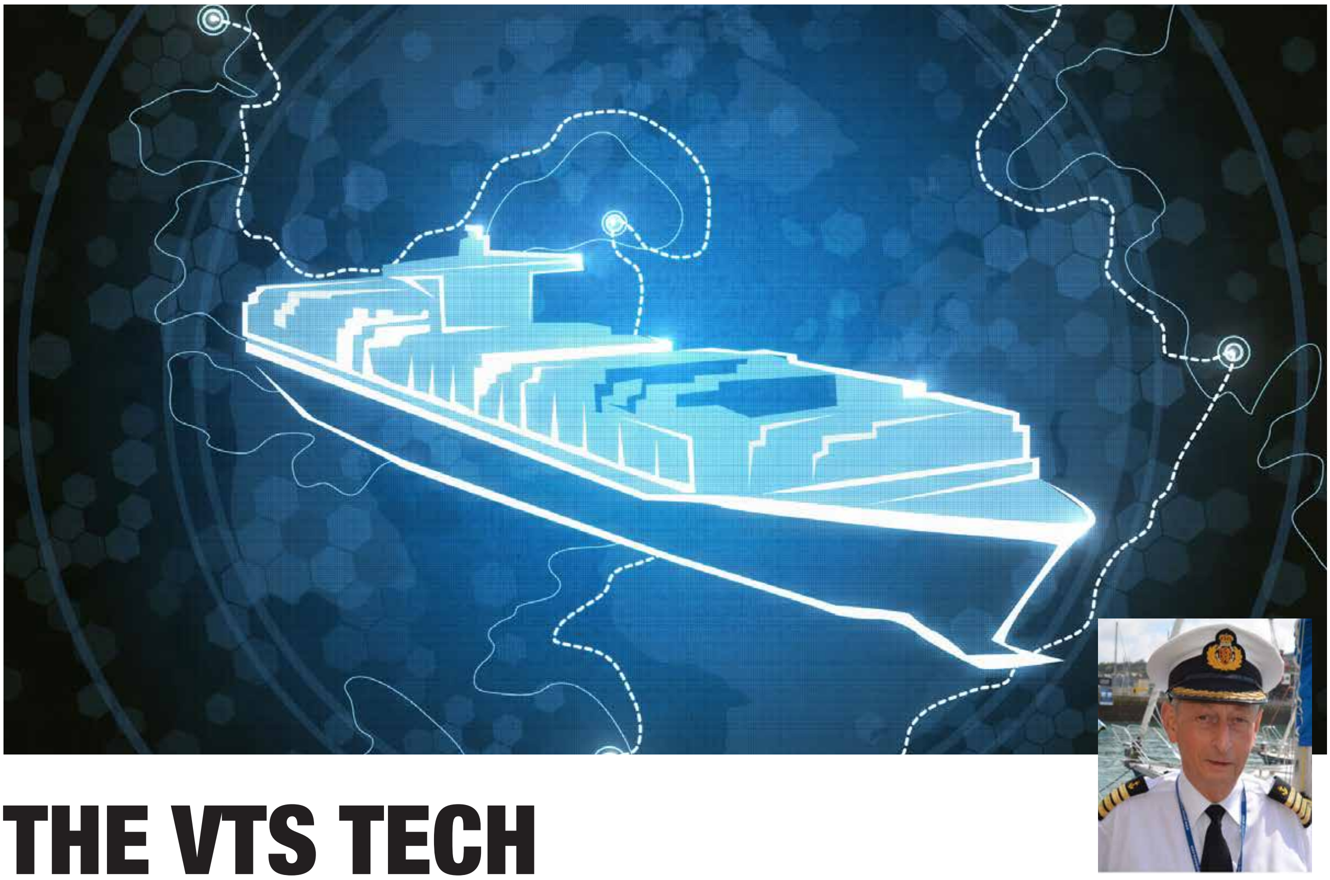

# THE VTS TECH REVOLUTION

Cdre Barry Goldman, Representative at IALA/VTS for the International Harbour Masters' Association, Banstead, Surrey, UK

READ VTS NEWS HERE

The first meaningful IMO guideline on Vessel Traffic Services (VTS), IMO Resolution A.587(14) was issued 33 years ago in November 1985. This was updated in November 1997 to the current IMO Resolution A.857(20). In the 22 years since, there has been a revolution in technology, and VTS has matured into the professional and formally certificated organisation that we see today. However, changes are in motion that should see subtle modifications dispel common misconceptions that have developed over the years.

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) coordinated a submission calling for the current IMO resolution to be reviewed and updated. The IMO's Maritime Safety Committee (MSC) approved this submission at its 99th session in May 2018 and passed it to the sub-committee on Navigation, Communications and Search and Rescue (NCSR) for action. This review is progressing well and the expectation is that a revised IMO Resolution providing a new Guideline on Vessel Traffic Services should be approved in November 2021 with implementation shortly thereafter. A significant proportion of the review and update should be relatively self-evident and uncontroversial, and will simply bring the resolution into line with current developments and practices. There are, however, two areas where we now have the opportunity to consider more radical solutions to overcome existing confusion and misinterpretation: the Types of Service and the concept of results-oriented instructions.

Types of Service have long been a source of debate. Thirty-three years ago, the terms Information Service (INS), Traffic Organisation Service (TOS) and Navigational Assistance Service (NAS) were first introduced in the initial IMO Guideline on VTS and the current resolution implies that it is up to ports to declare which of these services it provides and that the level of provision is optional. As a result, a number of VTSs only declare INS and a large proportion do not declare NAS. Looking at this from a more practical standpoint, a VTS is just one of many mitigation measures available to reduce risk to as low as reasonably practicable. It is, however, one that involves a very significant investment in infrastructure, staff and training.

It is inconceivable that a port would invest in a VTS to mitigate risk and then use it only for providing information, with no role in organising vessel traffic. If a VTS is implemented to reduce risk, it is undoubtedly going to organise traffic. Equally, a VTS operator is not going to stand by and do nothing if a vessel is standing into danger; an operator would intervene and all VTS Operators are trained to do so. Despite clarification issued in an IALA Guideline on Types of Service in 2012, confusion over service provision continues. The current resolution also differentiates between coastal and port VTS, indicating that a coastal VTS would normally only provide INS. In practice, Coastal VTS operators will, and do, intervene if a vessel is standing into danger, and will also attempt to manage traffic within the legal basis of the coastal VTS. Therefore, the distinction between a port and coastal VTS is misleading and completely unnecessary.

From the mariners' perspective, the subtleties of the different types of service are unnecessarily complex. The specific types of service provided will probably not even have registered among the host of other information that has to be researched before entering port or passing through a coastal VTS. Having established that the port has a VTS, the Master might reasonably expect to be provided with the following:

- Basic factual information relating to the vessel's arrival;
- Movements through the approach channel, the embarkation of the pilot and the passage into port will be deconflicted with other vessels;
- The entry into port will be managed and organised;
- Should the vessel start heading towards the wrong pilot station or towards a navigational danger or shallow water, the VTS would warn and advise.
- A survey by the Nautical Institute identified that many mariners don't recognise that there are three distinct types of VTS service nor is there any practical reason for them to do so.

The draft of the new resolution seeks to remove this confusion by deleting all reference to Types of Service and any suggestion that such provision is optional. Either it is a VTS or it is not a VTS; it is only the high-level functions of a VTS that will be set out in the new document and this should improve world-wide harmonisation of services. This approach has recently been clarified by IALA with the issue of guidance to ports where risk assessment indicates that a VTS is not necessary but recognises that information will still need to be communicated to ships using the port. In these circumstances, qualified operators are not required and the guidance advises that they identify themselves as a "Local Port Service" to avoid any suggestion to mariners that VTS capabilities, such as traffic management or oversight to provide navigational warnings or advice, are provided.

Nothing in the current resolution has caused so much confusion to VTS operators and trainers than the statement that 'instructions should be result-oriented only'. No other term has been quoted so widely - and interpreted so differently - by those seeking to justify their own particular

ends. The intention was simply to ensure that the Master's ultimate responsibility for all aspects of the operation of the ship was respected. As long as this is clearly understood by both VTS operators and Masters alike, there is absolutely no reason why advice cannot be given as long as the advisory intent is clear. The new IMO resolution will focus on the ultimate responsibility of the Master, leaving subordinate documentation to provide details on communications procedures. Standard Marine Communications Procedures (SMCP) is deficient with regard to VTS communications procedures and work is already in progress within IALA to develop guidance on communications procedures taking note of air-traffic procedures as examples of best practice; this should help to improve world-wide harmonisation of VTS communications.

The lack of simplex channels allocated to port operations is another area where changes to VHF channel allocations reflected in the ITU Radio Regulations 2016 offer potential benefits to VTS. These changes were largely driven by the need to provide for digital data in support of the e-Navigation initiative. Two simplex channels, 87 and 88, had previously been formed and allocated to port operations with the splitting of two duplex circuits to provide for AIS but no mandatory carriage requirement was promulgated. The latest Radio Regulations identify two further duplex circuits that have been split to provide further channels for AIS and these also provide two simplex channels, 1027 and 1028, for port operations.

The IMO requires communications equipment to be compliant for all changes by the by the first survey after 1 Jan 2024. By 2025 there should be four more channels available that are dedicated to port operations. The 2016 Radio Regulations also provide for four existing duplex channels, 78, 19, 79 and 20, to be split into eight simplex channels, all with four-digit designators, with equipment required to be compliant by 2025. It is for national administrations to decide whether to use these channels in the duplex or simplex mode and selection of the appropriate channel number will ensure that ships automatically select the appropriate mode. In the EU, however, for reasons that are not entirely clear, it has been decided that only the duplex mode will be used. Consequently, within the EU four, and outside the EU twelve, additional simplex channels will be available for VTS use from about 2025; this should provide welcome relief to problems of mutual interference between adjacent VTSs both nationally and internationally. Implementation of all these changes may still be a few years off but they offer the prospect of some significant improvements in VTS operations.

## ABOUT THE AUTHOR

Commodore Barry Goldman had a 36-year career in the Royal Navy and was appointed CBE in 2001 before joining the Port of London as VTS Manager where he remained for over a decade. He assumed the duties of Harbour Master for the Ports of Jersey in 2012 before retiring in 2014. Barry is currently IHMA's representative at IALA.

## ABOUT THE ORGANIZATION

The International Harbour Masters' Association is the professional body for those with responsibility for the safe, secure, efficient and environmentally sound conduct of marine operations in port waters. With members in more than 50 countries, the Association brings together all those who hold a managerial position in aspects of the control of marine operations within a port.

## ENQUIRIES

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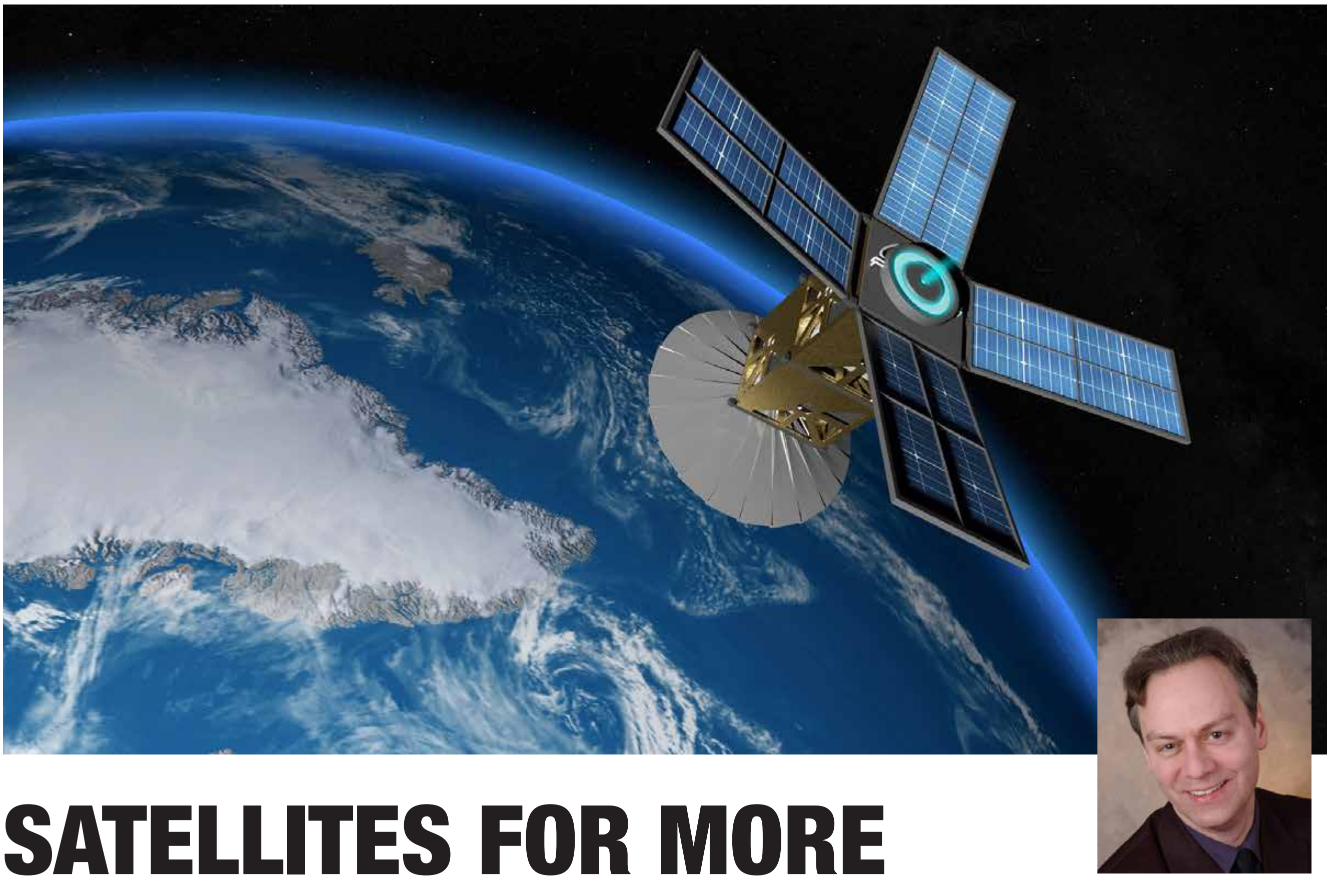

# SATELLITES FOR MORE SAFETY AND EFFICIENCY IN MARITIME OPERATIONS

Dr. Nils Meyer-Larsen, Project Manager and leader of competence area 'Maritime Security', Institute of Shipping Economics and Logistics (ISL), Bremerhaven, Germany

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SATELLITES IN MARITIME

Satellite-based services have a great potential to support the marine and maritime community. Parties like fisheries, coast guards, port authorities, shipping companies, research institutions, and many more, will considerably benefit from related innovative services in their daily work, offering a wealth of information on the oceans and coastal areas, e.g. on a variety of environmental variables, near-real time ice information, and Satellite-Derived Bathymetry, supporting marine and maritime activities and safety of navigation.

Increasing safety and efficiency and reducing the risk of operations is one of the core ambitions of carriers, ports and stakeholders in the maritime industry. In recent years, networks have developed and evaluated solutions to aid planning and vessel routing in higher latitudes, to increase safety of navigation in coastal areas which were inadequately surveyed, and developed relevant information portals and software solutions.

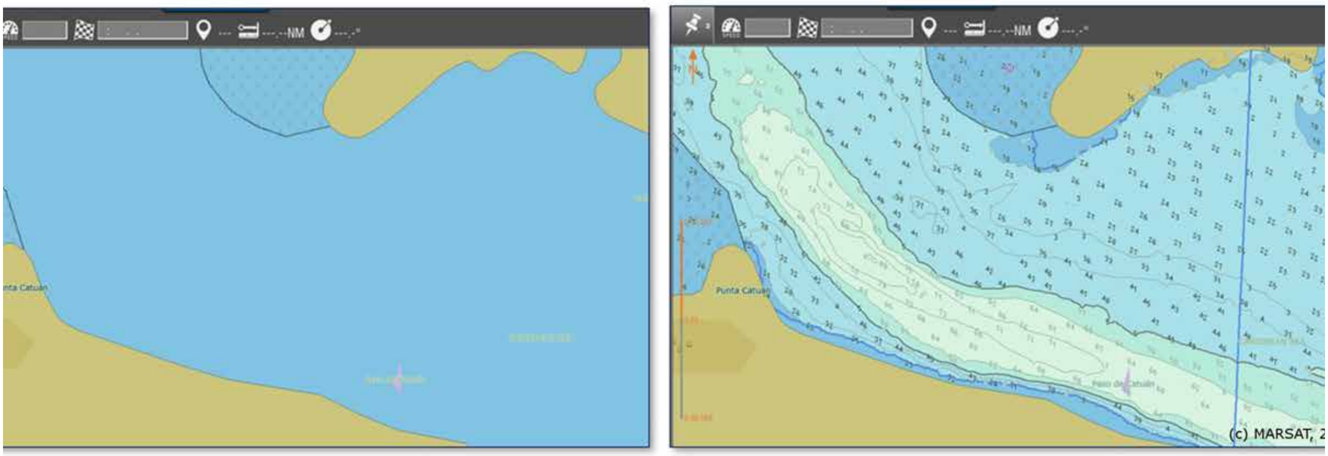
In July 2019 MARSAT, a German consortium that combines experience and expert knowledge in the fields of satellite data provision and analysis, software development, and maritime services, officially completed the R&D stage of the project and reached the next, mature level, offering satellite services for the maritime industry.

Among its partners, MARSAT includes EOMAP GmbH & Co. KG, Seefeld, Drift & Noise Polar Services GmbH, Bremen, SevenCs GmbH, Hamburg, Trenz AG, Bremen and the Institute of Shipping Economics and Logistics (ISL), Bremen/Bremerhaven.

MARSAT offers new services providing detailed data on sea ice in Polar Regions where internet connections are slow, improved electronic navigational charts for poorly surveyed waters and software solutions to support maritime decision-making with satellite data.

## TOWARDS SMARTER ROUTING IN HIGHER LATITUDES

Commercial shipping in the Arctic is expected to increase in the coming years. Ocean routes like the Northwest Passage above North America and the Arctic route north of Russia have the potential to considerably shorten vessels' voyages, e.g. from Asia to Europe from 40 days through the Indian Ocean and Suez Canal down to about 30 days, drastically reducing shipping costs. However, operating in these areas puts special requirements on shipping companies and their crews. One crucial topic of networks like MARSAT is fully automated, 24/7, near real-time ice image information for polar waters, where




The difference SDB can make. The currently available, official electronic nautical chart of Bahia Catalinita in the Dominican Republic (left) and the improvements made by the integration of Satellite-Derived Bathymetry data (right).

Internet connections use the Iridium satellite network, a costly solution with bandwidth of only a few kb/s. Access to relevant data portals or even normal web pages is a challenge, if not impossible. Until now this limitation has hampered the use of detailed ice information on board and the availability of high-quality ice information.

MARSAT has developed a support system for tactical decision-making, including an operational satellite image database, communication channels between ships, satellites and the internet, the automatic ship identification system (AIS), and the so-called Ice Pad. The Ice Pad is a special hardware device developed to transfer satellite imagery and ice data to ships in a highly optimized manner, including areas where only a low-bandwidth Iridium connection exists. As an example, MARSAT supported the Weddell Sea Expedition 2019 to Antarctica, conducted by an international team of researchers on the South African research ice-breaker S.A. Agulhas II. It was shown that the Ice Pad provided the captain with valuable detailed near-real time ice information which would hardly be accessible otherwise.

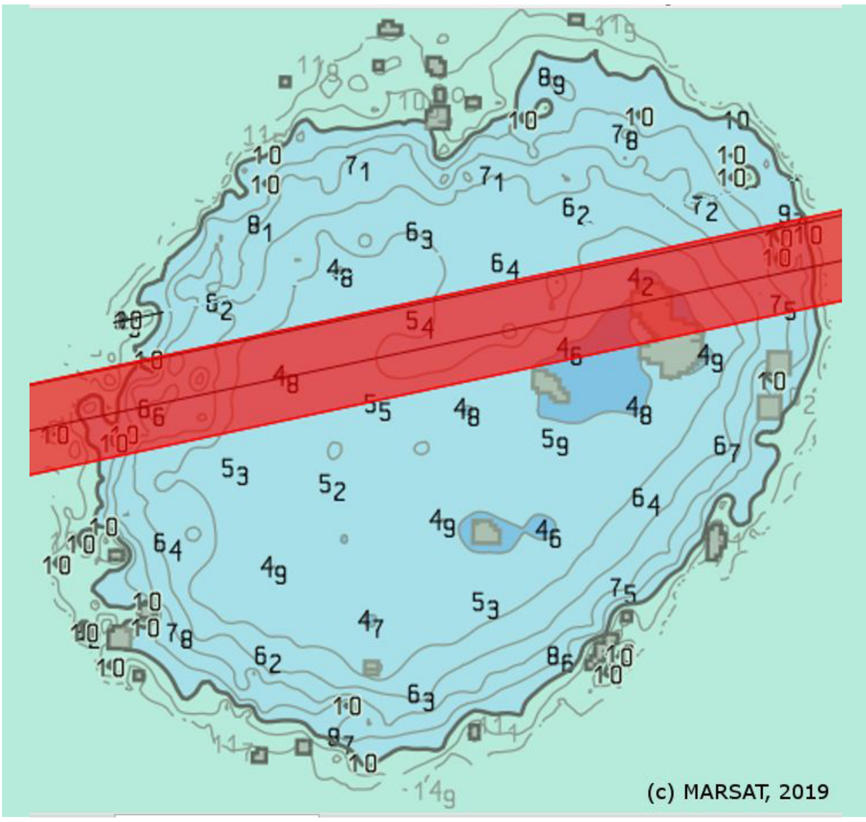
## UPDATING ELECTONIC NAVIGATIONAL CHARTS BY SATELLITE-DERIVED BATHYMETRY

According to the International Hydrographic Office (IHO), approximately 50 percent of the world's coastal areas are not or not adequately covered by nautical charts. Satellite-Derived Bathymetry can support. It calculates water depth for shallow waters using sunlight reflected from the seafloor and recorded by satellite sensors. Although the technique has been investigated since the 1970s, it required modern satellite capabilities and advances in computing power to bring SDB, as it is often called, to the broader community. Using satellite data to survey shallow waters brings many advantages compared to labour- and equipment-intensive acoustic campaigns.

There is a steady growth in uptake of Satellite-Derived Bathymetry. Most applications are in planning and management of coastal zone environments and in engineering. Hydrographic applications have been less common so far, although some hydrographic offices are starting to systematically integrate SDB into their surveys. The MARSAT team has generated high-resolution and dense-contour electronic navigational charts (ENCs) complying with current standards. These charts are especially helpful to mariners in areas which are inadequately surveyed.

A recent incident which highlights the usefulness of SDB for maritime navigation is the grounding of 185 metre-long container vessel Kea Trader on 12th July 2017 near New Caledonia. According to the respective investigation report , one of the reasons which lead to the accident was the fact that the respective ECDIS (Electronic Chart Display and Information System) navigational chart only showed an isolated danger symbol near the path of the vessel, not indicating that the symbol in fact depicted the Recif Durand reef, about 1 km in diameter midway between the islands Ile Walpole and Ile Marie. The crew remained unconcerned by the vessel passing so close to the isolated danger and incorrectly assumed safe water within the planned route. When passing over Recif Durand, the Kea Trader navigated into shallow waters and remained stranded, eventually causing total loss of the vessel.

The MARSAT team subsequently performed an SDB analysis of the respective area. Using this innovative technology, it was possible to analyse the water depth in the vicinity of the Recif Durand reef in detail, as indicated in the picture below, which also shows the route of the Kea Trader (in red). Thus, if navigational charts are complemented by SDB information, it can help to avoid accidents like the grounding of the Kea Trader in the future.




Recif Durand reef, surveyed by Satellite-Derived Bathymetry. Conventional navigational charts only show an isolated danger symbol. In red the planned route of the Kea Trader.

## SMART DECISIONS BASED ON DIGITAL DATA

The demand from the maritime industry for up-to date spatial information provided by satellites is obvious and much of the potential is yet to be explored. The MARSAT team has analysed the market demand and potential of satellite analytics in more detail. One of the demands of the maritime industry is the ability to access data and perform analysis in-house, as and when they need it. MARSAT has developed cloud-based software solutions to harness satellite data through modern data analytics methods in combination with physics-based procedures. Easy-to-use web-based tools aid maritime decision making, including information portals especially for the maritime industry. These harvest available data such as global sea-state models and also allow users to access very high-resolution data from satellites. For example, the dredging industry uses these services to support sediment monitoring and seafloor characterisation.

### ABOUT THE AUTHOR

Dr. Nils Meyer-Larsen is Project Manager at the Institute of Shipping Economics and Logistics (ISL) in Bremen/Bremerhaven, Germany, and leader of the ISL competence area 'Maritime Security'. He has managed several national and international research and development projects in the fields of maritime transport and supply chain resilience as well as satellite-based services for the maritime industry.
Contact: meyer-larsen@isl.org

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# THE PURPOSE OF VTS

## EFFICIENCY, SAFETY AND ENVIRONMENTAL PROTECTION

Anders Johannesson, VTS Training, Senior Advisor, Research and Innovation, Swedish Maritime Association, Sweden; Katie Aylward, PhD student, Maritime Human Factors Unit at Chalmers University, Gothenburg, Sweden

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After World War II, the rebuilding of Europe led to rapid developments in shipping. There were increasing industrial demands for raw materials and pressure on the supply chains to be more efficient and reliable. In navigation, one of the most difficult obstacles to overcome is fog. Traditionally, navigation in and out of ports was suspended in heavy fog conditions and vessels had to anchor nearby until visibility improved. This often led to congested logistic chains. Experts decided the most reasonable solution was radar.

However, the cost of radar was a major issue for shipping companies. Therefore, it was decided to place the burden on the shore side. The ports provided their pilots with radar stations that could be used to pilot all vessels calling at the particular port. This concept was successfully tested with one pilot aboard the vessel and one ashore giving directions using radar. This resulted in the first goal of VTS being fulfilled: Efficiency.

With the shore-based radar system in place, concerns were raised about safety. Did navigating under radar surveillance in adverse conditions cause more accidents than before? On the contrary, the vessel traffic was clearly increasing, yet the rate of accidents diminished. The second goal of VTS- Safety- seemed to be fulfilled.

During post-war decades, the demand for oil rapidly grew and the world witnessed disastrous tanker accidents. Again, the nautical expertise turned to shore-based radar, which meant a vessel going astray could be detected and warned before it grounded or collided. The third goal - Environmental Protection – was also being achieved.

There are many milestones in VTS history. In the 1940s, the first milestone was that radar told the operator that something was coming, and if this something was either coming the right way or the wrong way. The next milestone was AIS (Automatic Identification System) in the 1990s, which told the VTS Operator who was coming. The third milestone, currently being implemented, is STM (Sea Traffic Management) which indicates the intentions of the incoming vessel. This article is about STM, the third milestone, and the possibilities and potential impact this will have within the VTS.

### A PROACTIVE VTS

As previously described, the key goals of VTS are Efficiency, Safety and Environmental Protection. Most VTS personnel including; operators, supervisors, and managers, agree that these goals cannot be achieved without a proactive approach from the VTS. Possible incidents or accidents must be predicted and prevented (i.e. a warning or alert must be issued to a vessel in danger). The core working procedure for VTS operators can be summarized by the following points:

- The VTS Operator discovers a potentially dangerous situation, or a vessel acting in an unusual way (e.g. a vessel navigating in the wrong side (port side) of the channel). Depending on the


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surrounding traffic, this might be a risky situation.

- The VTS Operator will then (usually by VHF radio) call the vessel to alert it about the situation and provide assistance out of the troublesome situation. Depending on the severity of the scenario, simple advice to keep to the starboard side of the channel might be enough.
- After providing advice to the vessel about how to avoid the danger, the VTS Operator will ensure that the suggested solution is carried out and provide further advice and instructions if deemed necessary.

Naturally, the faster, clearer, and more accurate the action of the VTS Operator, the higher the probability that the potential accident will be avoided. Prior to STM, the VTS Software System to discover dangerous situations used 'dead reckoning' and assumed that vessels would retain course and speed, thus calculating upcoming positions. This requires a significant level of human involvement, which has advantages and disadvantages. There is a clear need for proactive work from the VTS. There must be enough time to alert and inform the vessel, and its´ crew must have time to react, respond and take proper action. In general, if you have a sensible plan you are likely to have a good outcome. If you share your plan with experienced, objective and trustworthy people who can provide feedback, success is more likely. Then, if you share your plans with all other involved parties, the risk of misunderstandings is minimized. The STM technology and infrastructure enhances these proactive features.

## STM FUNCTIONALITY

The STM concept is based on information sharing and interoperability between various software systems. The primary information to be shared is the vessels voyage plan. Sharing this information with all actors could lead to a common situation overview and help promote proactive work. However, STM offers many more

| | |
|---|---|
| **Ship to shore route exchange** | There are two situations when this feature can be used: in the planning phase of the vessel´s voyage to show the VTS its intentions or |
| **Route cross check** | sending the route that they are monitoring during the voyage. In both cases the vessel submits its plan which shows its intentions to the VTS. |
| **Chat** | The VTS can review a route received from a vessel. |
| **Sending routes shore to ship** | Similar to Skype, but it is carried out by the means of ECDIS or a VTS software system. |
| **Route based prediction tool** | The VTS Operator can either edit the vessel´s route, make a new route or retrieve a route from a database and send it to the vessel. The route will automatically be presented as a suggestion on their ECDIS. |
| **Enhanced monitoring** | The VTS can use this feature to predict congestions and hazards. These calculations are based on the submitted voyage plans rather than dead reckoning. |
| **Sending S-124 areas** | If the vessel deviates from the monitored route, the VTS Operator is alerted by the VTS system. |
| | THE VTS OPERATOR CAN SEND AN AREA THAT WILL BE DISPLAYED ON THE VESSEL´S ECDIS. THE INFORMATION COULD INCLUDE RESTRICTED AREAS, SEARCH AND RESCUE OPERATIONS, ETC. |

possibilities for information sharing. Listed below are the features developed within STM which can enhance efficiency, safety and environmental protection.

### SIMULATOR TESTS, THE EUROPEAN MARITIME SIMULATORS NETWORK (EMSN)

In general, testing new technology in a controlled and safe environment is preferred. In Europe, navigation bridge simulators are usually hosted by educational centers including merchant marine academies, research institutes, national maritime administrations etc. for training, research, and education. The European Maritime Simulator Network (EMSN) was developed, which consists of twelve simulator centers and has the capacity to host 30 manned bridges in the same simulator scenario, interacting with each other and with the VTS. Simulator scenarios were developed by subject matter experts, one with dense maritime traffic, and another with less traffic to assess the utility of the services in various traffic conditions. A VTS shore center was also established in the simulation set-up to function as a typical VTS center throughout the simulations.

Four weeks of simulation trials within the EMSN were conducted in the fall of 2018 and spring of 2019. The first two weeks were baseline tests in which no STM Technology was used (navigation as it is today). The last two weeks followed the exact same experimental design but instead used STM technology. The baseline and STM simulations were compared with each other.

The VTS Operators manning the VTS station were experienced but had no experience working in these particular VTS areas of the simulator scenarios. The data from the VTS was captured using two methods: observations of all interactions between the vessels and VTS (i.e. which STM services were used), and post-test questionnaires given to the VTS operators to obtain feedback related to the STM services. Results from the simulations showed interesting patterns in both the work flow of the VTS and the use and preference of the STM features.

### RESULTS FROM THE SIMULATIONS:

The ship-to-shore route exchange service was used very frequently throughout the simulations and is thought to be one of the most useful features developed within the STM project. Once the route is shared, the VTS operators can review, edit and send back a route to the vessel. This feature is helpful as the route directly sent to a vessel´s ECDIS where the bridge team can easily review the route. This is a major change from today, in which the coordinates must be verbally transmitted over the VHF radio and must be manually plotted by the bridge team. Every time a route was sent from the VTS to a vessel, the proposed route was supplemented with a chat message. Chat was appreciated according to the post-test questionnaire. However, the introduction of the chat function, along with the route sharing features, led to a significant reduction of VHF communication. It was observed that VHF communication was reduced by approximately 40 %.

The route-based prediction and enhanced monitoring tools were the least used during the simulations, as both require a deeper understanding of the VTS system and the features of the new STM technology. Further testing is needed to understand the impact of these services. The S-124 feature allows the VTS Operator to send data directly to the vessels´ ECDIS screens. This is a significant change from today in which this information must be sent by Navtex or transmitted via VHF radio. This service was greatly appreciated by the navigation teams, as it reduced the manual workload on the bridge.

### CHANGE IN INTERACTIONS BETWEEN SHIP AND SHORE

The current means of communication in shipping, VHF radio, is public, which means anyone can overhear the conversation between ships and the VTS or ship-to-ship. It is compulsory to continuously monitor the VTS working channel. This practice brings domain and situational awareness to all actors within the VTS area. Should a vessel enter the area, leave berth or drop their anchor they will communicate this to the VTS which will update on the traffic situation. However, the value of overhearing is disputed. In some ports the amount of VHF traffic makes it impossible to filter out the irrelevant information.

Based on the results from the simulations, the introduction of new communication/information sharing technologies will change the usage of VHF radio. In both baseline and STM trials the frequency and details of interactions between vessels and VTS were recorded. The results showed that the number of interactions increased in both traffic scenarios and approximately twice as many interactions were recorded during the STM trials. The interactions initiated by the VTS also approximately doubled, when the STM tools were introduced. Further studies and investigations are needed to assess how and when chatting is preferred to VHF and when VHF still must be compulsory.

These results also present a question of workload. Given the possibility to review, edit and send back the Voyage Plans of the vessels, will this be manageable tasks for the VTS? Will current manning requirements at VTS stations be sufficient, or should the manning requirements be re-assessed? These are questions which must be explored in further research.

### WILL EFFICIENCY, SAFETY AND PROTECTION OF THE ENVIRONMENT BE ENHANCED BY USE OF THE STM TOOLS?

Although it is impossible to draw major conclusions from controlled simulation exercises, some preliminary observations can be made. The STM services promote a more pro-active and transparent approach to VTS work and foster more collaboration between ship and shore. The ability to make a plan and share it with others is an exciting aspect of STM, and if properly implemented has the opportunity to enhance efficiency, safety, and environmental protection. More research on work practices and procedures within the VTS, the effects of automation, cybersecurity, and other areas are needed to understand the full impact of the STM services within all aspects of the complex socio-technical system of shipping.


### ABOUT THE AUTHOR

Anders Johannesson has 22 years in service at the Swedish Maritime Administration as VTS Operator and VTS Training Officer (responsible for national Swedish VTS training.) Since two years he is working as Senior Advisor at SMA´s Research and Innovation department.

Katie Aylward is a PhD student in the Maritime Human Factors Unit at Chalmers University in Gothenburg, Sweden. Her research focuses on the user experience of new technology implementation in both ship and shore-based applications. Prior to Chalmers, Katie worked as a Human Factors Specialist at the American Bureau of Shipping (ABS) in Houston, Texas.

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# BOLLARDS IN TERMINALS

## DESIGN AND ISSUES

José Ramón Iribarren, General Manager; Luis López, Head of Mooring Arrangement and Offshore Department, Siport21

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Operational safety is a significant challenge in the poprts and terminals industry, and this has been affected by the growth in recent of years of various sectors, which in turn has been accelerated by pressure from public and private stakeholders. An example where this has been particularly true is the cruise market, where terminals have come under pressure to receive ever greater numbers of vessels for both economic and publicity reasons.

This situation has led to operate these larger vessels in already existing infrastructures, generally designed for smaller ships or even for other types of traffic, where the demanding mooring conditions imposed by these large ships has proven to be insufficient.

Due to the characteristics of these ships, large dimensions and very significant windage area, they are provided with mooring equipment that includes a large number of mooring lines, showing high resistance capacity. In general, the mooring system optimization is not easy considering the limitations imposed by bollards, fenders and quay arrangement, especially in cruise terminals designed for smaller ships.

Usually, cruise vessels, for example, are expected to operate under not very demanding weather conditions due to the seasonal traffic, but sometimes they might eventually be exposed to extreme conditions, scenarios which challenge the response of mooring and fender equipment. Occasionally, the capacity of these elements is exceeded, with the corresponding consequences: bollard or fender failure, or even breaking of the berth structure itself due to the mooring and fender loads. Modern cruise vessels avail high strength lines (HMPE or similar materials), with MBL values which might be higher than the resistance of conventional bollards.

All agents involved in safety of maritime operations are sometimes forced to take decisions with only partial knowledge of the real resistance of the mooring equipment on the cruise terminal and of the real effect of the mooring conditions on the shore equipment.

This technical paper summarizes some of the main causes and analyzes them in order to produce some general recommendations derived from the experience of the authors applied in numerous projects. This description is valid both for the design of new terminals and for the adaptation of existing terminals.

### LARGE CRUISE SHIPS FEATURES

Large cruise vessels show the following characteristics:

- Ships with large main particulars
  - o Length and beam: Maximum cruise vessel “Oasis of the Seas” class 363 m compared with maximum

containerships 400 m or LNG carrier Q-Max 345 m
    - o Huge area exposed to wind, both frontal and transverse, this is an important factor as it determines the magnitude of the wind forces.
    - o Relative low draft and displacement, as these are typical ships governed by the volume and not by the displacement.
- Mooring equipment:
    - o In general, high performance synthetic ropes (HMPE, aramid, …) with fiber tails
    - o Mooring lines with minimum breaking loads (MBL) greater than 100 t and sometimes over 150 t per line. The design capacity of the rest of the mooring equipment onboard (winches, bitts, fairleads, rollers, …) depends on this value.
    - o Typical mooring arrangement for cruise vessels usually requires between 16 and 20 mooring lines, although the largest ships can have up to 22 mounted on drums and some additional mooring lines connected to bitts.
    - o High standard (quality and performance) of mooring equipment.
- In some cruise vessels the breadth of the upper decks is greater than the design beam at the waterline, which can lead to compatibility issues due to the invasion of the area above the quay by the upper decks and lifeboats (clash with existing infrastructures such as cranes and fingers).
- Great height of the mooring deck, which results in tending mooring lines with high vertical angles. These mooring lines show a low performance during mooring conditions (limited efficiency in horizontal restriction).

Fig. 1. Vertical mooring lines

### BERTH LAYOUT AND SHORE MOORING EQUIPMENT:

The issues concerning the mooring of cruise vessels depend not only on the characteristics of the ship, but also on the berth layout and on the characteristics of mooring equipment on shore. Some examples are as follows:

Sometimes ship length exceeds the available quay length leading to non-optimal mooring arrangements and to incomplete contact with the fender system. These high asymmetrical mooring arrangements show high dynamic response and low performance under demanding weather conditions.

Mooring on long quay walls imposing an asymmetric and non-optimal mooring arrangement with a highly asymmetrical distribution of loads on the different mooring lines.

Small gaps between ships moored in the same alignment. Depending on the number of bollards on the berth, it is very common to share connection points between ships. Due to the high number of mooring lines, sometimes more than 3-4 mooring lines, even up to 7 in extreme cases, from two different ships are connected to a single bollard. This configuration may also mean line crossing between adjacent moored ships.

Some terminals use elevated bollards to decrease the vertical angle of the breast lines, but this implies a complex structural arrangement on the berth and, usually, bigger structures supporting the bollards and increasing the interference with traffic, fingers or the use of the berth for other traffics different from cruise vessels.

Storm bollards are installed in some ports. These bollards are located in an inner position of the quay, far from the quay edge, allowing lower vertical angles and increasing the length of the mooring lines. The problems are related with traffic interference in the quay and relatively low performance of the full mooring arrangement, due to the mix of mooring lines connected to conventional bollards (usually short) and connected to storm bollards (longer and more flexible).

### FACTORS TO CONSIDER

The extension in the length of the cruise season is another factor that increases the risk of suffering harsh conditions during the stay of the ship at the terminal.

Regarding fenders, usually fender design is made based on berthing energy, but sometimes the most demanding conditions for fenders are the mooring conditions of large vessels during demanding weather conditions (combinations of waves and gusty wind producing a significant dynamic

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Fig. 2. Five mooring lines connected to one single bollard in cruise terminal.

effect). This is very important for terminals not designed for the larger cruise vessels.

One of the main issues affecting the operation and safety of large cruise ships at the terminals is the high number and capacity of mooring lines, along with the limited working load of most bollards currently installed. The use of terminals designed for other traffics or for smaller cruise ships might cause that the capacity of mooring lines exceeds the resistance of bollards.

As bollards are resistant elements the failure is usually unwarned, and the failure of one single bollard means the loss of all mooring lines connected to it. The sudden loss of a number of mooring lines can lead to the loss of the mooring capacity of the whole mooring arrangement (cascade failure).

As a consequence of operating these ships in existing terminals, the characteristics and conditions of bollards, fenders and infrastructure might not always be adequate for their size.

In recent years, the number of incidents related to cruise ships mooring has increased, and bollards failure constitutes a significant proportion of them. Therefore, all agents involved in the design and operation of cruise terminals should be aware to consider and review in which conditions the operation and permanence of these ships are carried out, and if safety level is enough.

## RECOMMENDATIONS

As it can be seen, from the point of view of the mooring and berthing conditions there are several factors affecting the operational and safety conditions of the moored cruise vessels on a cruise terminal. Some of them are common to different types of ships, but due to the characteristics of the large cruise vessels.

When designing a new terminal or adapting an existing terminal to this new large cruise vessels, it is important to address all these situations, as they have a direct impact on the operation and safety of ships.

A detailed analysis of the local conditions of each particular port is necessary in order to assess the safety of marine operations. The knowledge of the characteristics of ships and the issues found in other terminals and ports will help to find specific solutions to specific terminals.

## ABOUT THE AUTHORS

Jose R. Iribarren
Managing Director Siport21
Naval Architect (TU Madrid). Founder of Siport21, he manages, plans and implements corporate policies and strategies. He is specialized in studies on moored ship dynamics and ship manoeuvrability in port areas. “Gustave Willems Prize” (PIANC) and “Modesto Vigueras Prize” (PIANC Spanish Section).

Luis Lopez
Head of the Mooring and Offshore Department Siport21
Naval Architect (TU Madrid) and Master’s Degree in “Numerical Methods for Engineering Design” (TU Catalunya). He is specialized on moored ship dynamics using numerical models. Member of different PIANC Working Groups and Joint Industry Projects.

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Pioneer in the installation and implementation of numerical ship manoeuvring models and ship manoeuvring simulators in a private company in Spain. Since 1999, Siport21 has developed close to 1.000 technical studies spread out over almost all the Spanish coast and they have worked in 46 other countries. Also, the company has trained more than 1.500 seafarers from 50 international shipping companies in their Simulation Center.

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