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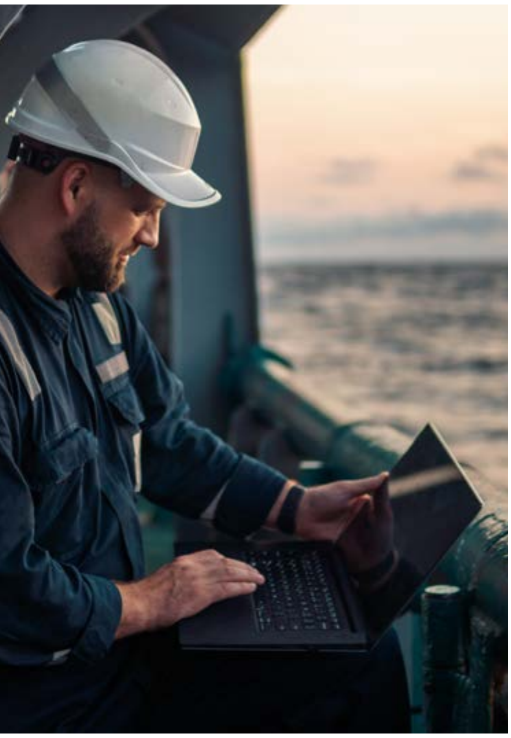
Maritime Communications
- A look over the horizon






Section 01
Basics of marine communications

Chapter 1: Satellite systems and networks explained

Explanations of different network configurations, GEO, LEO, MEO

Electromagnetic spectrum L-Band Ka, Ku, C-Band

VSAT

Chapter 2: GMDSS & regulatory communications

Requirement for satellite equipment and approved service providers

LRIT and SSAS

Maritime Single Windows and e-NOAD (US requirement)

Chapter 3: Commercial communications

Look at the operational traffic generated by ships and differences between trades/sectors.

Container monitoring at sea

Chapter 4: Crew & passengers

Communications as a revenue stream and for welfare purposes/crew retention.

Crew connectivity survey findings.

Section 02
The connected ship

Chapter 5: Performance monitoring

Impact of efficiency regulation on ship generated data traffic, fuel use, speed, weather routeing.

Ability for shore office to access systems and configure as required.

Compare performance across fleet, grouping for trade/type

Chapter 6: Remote operation and assistance

Emerging field of operation requiring robust and reliable connectivity at sea.

Prelude to autonomous ships

Chapter 7: VR, AI and maintenance methods

Connection with third parties for repair and maintenance, remote surveying, digital twin data transfers

Chapter 8: Cybersecurity

Basic concepts, disseminating best practices for crew/contractors. IMO guidelines

Onboard network architecture, network protection.

Ship-shore data transfer security

Third party systems and management of security, virus monitoring, Section 03

Special services

Chapter 9: Onboard training

Simulator and Computer Based Training services from third parties,

Chapter 10: Telemedicine

Third party services, ensuring connectivity during emergency assistance

Management of medicine chest, crew medical records

Chapter 11: Future communication planning

Anticipating future communication needs.

New service providers, impact of future technology and 6G communications

Section 01

Basics of marine communications

01

Satellite systems and networks explained

Getting to grips with basics

Shipping is frequently described as a conservative industry that is slow to embrace new technologies. In fact, this is not true especially when it comes to the matter of communications. Ships were communicating with the shore via radio from 1899 although initially messages were sent using morse code rather than voice. By the late 1970s, satellite communications were being used by a small number of commercial vessels and many more military ships.

Obviously technological change is only adopted once it has reached a stage where it can meet the unique demands of the maritime industry and in particular prove its reliability and robustness under the harshest of conditions. If shipping has been slower to embrace some aspects of modern technology, it is often because the difficulties and high cost of communications across vast distances has meant that ship operators devised ways of minimising the amount of communications needed for commercial purposes.

Few ship operators or their crews are concerned with the high science and engineering of the satellites themselves, but they do need to understand the fundamentals of satellite communications and the radio spectrum.

Satellite communication is in principle no different from radio communication and in fact both systems operate in an identical manner making use of electromagnetic waves. Conventional radio equipment is intended for communications between two points only except when a distress signal is being sent. Radio clearly has one characteristic that has been a restricting factor and that is the signal has a very limited range in comparison to satellite networks. While some radio signals can bounce off the ionosphere extending the range this is not as effective as bouncing signals using satellites.

A satellite is an intermediate device in orbit above the earth that enables transmission of data to a ship or receiving data from a ship regardless of the different positions on the surface of the globe of the two parties. The other party can be a shore office or another ship.

All satellites make use of a beam which is a pattern of electromagnetic waves received or transmitted by the satellite. The transmission from a satellite has a defined pattern and the beam can be wide or narrow covering a large or small area on earth. Using a system of varying frequencies and alignment of antennas onboard the satellite, each satellite can have several beams within which all or most of the satellite's power is concentrated.

The antennae on the ship are rarely stationary due to the constant movement of the vessel when under way and thus require the dish to be mobile in all dimensions. The dish itself is hidden from view by the radome cover but viewed up close they are sophisticated pieces of equipment with motors and gearing enabling the dish to maintain a lock on the satellite under all but the harshest conditions.

Most satellite communication systems are structured so ships are required to share channels with others which is perfectly fine for simple communication needs but highly inefficient when dealing with the large quantities of data that some operators generate. This can be overcome by making use of a very small aperture terminal (VSAT) service.

Subscribers to VSAT services are provided with exclusive or semi-exclusive use of satellite channels for sending and receiving voice and data at broadband speeds (although a VSAT service is not necessarily needed for broadband). Usually, they are charged for this on a monthly fixed fee subscription basis (although there may be limits on the data allowed before extra charges apply) as opposed to the rate per Mbit charged when using basic services. This enables a network to be created that permits the transmission of large quantities of data.

Not all ship types or fleet managers need large data flows for commercial reasons but passenger, offshore and container operations frequently do. For passenger vessels this will involve allowing passengers to use computers, tablets and smart phones as well as providing entertainment services. In the offshore industry it enables survey and other data to be transmitted at will and for container ships there is a need for large amounts of data for stowage plans and customer services.

Satellite networks

Competition for marine traffic is fierce and there are many players within the marine communications sector. They are however not all competing in the same market sectors. Not all satellite systems are identical, there being three main types: LEO (low earth orbit) MEO (medium earth orbit) and GEO (Geosynchronous Equatorial Orbit or more commonly called geostationary).

Each of these types of systems have their pros and cons and some ship operators will sign up to services on different systems.

GEO networks

These satellites are the most powerful type of satellite and are located in an orbit 35,768 kilometers above the earth's surface at a point above the equator. As their speed and direction matches the earth's rotation they are always fixed giving meaning to the term geostationary.

The satellites have a large beam and cover a very wide area meaning that fewer satellites are required to cover the same area as other network types. Inmarsat, the first commercial maritime satellite communication system, is of this type and although it is the leading player it is not alone and there are several other players offering maritime communications and VSAT services using GEO satellites including Thuraya which is in the process of refreshing its fleet of satellites the oldest of which is now over 12 years old.

Inmarsat initially operated with three satellites spaced around the equator with each satellite covering approximately one third of the world's surface but not extending to the polar regions above 70 degrees. Since the 1990s it has had a minimum of four satellites in service.
Inmarsat is currently in its 5th generation of satellites – all of the first four generations were limited to the L-Band with the latest generation operating on Ka-Band. In 2021, two third generation satellites provide maritime safety back-up services only and the fourth (4 L-Band satellites) and fifth generations (5 Ka-Band satellites) also provide maritime safety and fully commercial communications. Increasing demand for VSAT and improved 5G connectivity for both commercial and personal use at sea is driving growth in this arena. Satellite operators are investing heavily in new satellites to increase maritime VSAT capabilities and invariably the new satellites are of the HTS (high throughput satellite) type. In June 2021 Inmarsat announced its new Orchestra service which will take satellite and 5G communications a step further. ORCHESTRA will be a seamless configuration of its L-Band and Ka-Band networks with terrestrial 5G, targeted LEO capacity, and dynamic mesh technologies.

LEO networks

Closest to earth are the LEO constellations which typically comprise many small satellites orbiting the earth at between 800km and 1,600km above the earth's surface at speeds which see them completing an orbit normally in under two hours. They are ideal for very high speed, low latency communications, often exhibiting a delay of just 0.05 seconds.

Their small size and the limited coverage of each satellite means that a constellation comprising tens or hundreds of satellites is needed but this also gives the possibility for full coverage of the earth's surface including polar regions where GEO systems cannot operate.

LEO satellites are much smaller and less costly than other types making them ideal for newcomers.

Conceivably the best-known player in this sector is Iridium which has invested heavily recently to replace the ageing satellites it acquired cheaply in the early 2000s just a few years after the original constellation was established. There were 99 satellites in the original network. 66 in use, some in orbit as spares and some unlaunched
From 2017, Iridium has developed and launched a complete new constellation comprising 66 active satellites, with another nine in-orbit spares and six on-ground spares. The new satellites in the NEXT generation have more data capacity and have been instrumental in Iridium gaining recognition as the only GMDSS service provider apart from Inmarsat.

Iridium has a proven track record in maritime communications and its new satellites and broadband Certus offering along with GMDSS approval will ensure its future. There will likely be competition for future communications from the likes of SpaceX's Starlink network which will consist of tens of thousands of satellites providing broadband connectivity. The network has been controversial for various reasons including the impact on the environment, several scientists say it will impact visibility of the night sky and competitors have queried the legality of licenses issued to SpaceX, but launches have begun and more than 1,000 satellites were operational by summer 2021. Expected additional communication demand from ships as a consequence of growing digitalisation of shipping and also the imminent arrival of e-navigation whether mandated or voluntary is already being anticipated by new service providers. Advances in satellite technology means that satellites can now be much smaller and less costly than was previously the case. These so-called micro- and nano-satellites have the potential to bring new services and reduced costs for ship operators especially in niche and specialist areas.

MEO networks

MEO satellites orbit at a lower altitude than GEO, usually occupying the space between 5,000 and 12,000 km. Their relative proximity to Earth means they achieve far lower latency than GEO units, making them suitable for high-speed telephone signals and similar missions.

Depending on their altitude, MEO satellites usually complete one orbit of the Earth in between two and eight hours, although some can take up to 24 hours to orbit. Their smaller size and lower orbit means that between eight and 20 units will be required to provide complete coverage of the Earth.

Although more satellites are needed for a complete earth coverage MEO network, companies such as SES with its O3b constellation and Globalstar are among those investing in this sector and targeting marine customers.

High latitude coverage

The vast majority of merchant shipping trades are carried out in areas between the Arctic and Antarctic Circles which are a fraction over 66 degrees North and South respectively. This is near the limit of the 70 degrees latitudes that are the extremes of Inmarsat's GEO satellites meaning satellite communications (including GMDSS) at latitudes above 66 degrees cannot be guaranteed. This is one of the reasons the Iridium has been accepted as a GMDSS provider since its LEO network has no latitude limitations and is available right to the North and South Poles.

Maritime activity inside the Arctic Circle has been steadily increasing involving oil and gas exploration, some domestic commercial traffic but most recently growing use of the Northern Sea Route around the top of Russia connecting Asia and Europe.

There is also increasing cruising activity inside the Arctic Circle.

As a consequence, Inmarsat is expanding its GlobalXpress network with payload on two satellites planned to be launched by Space Norway and its subsidiary Space Norway HEOSAT as part of the Arctic Satellite Broadband Mission. The satellites carrying the GX payloads are scheduled for launch in 2022.

Iridium has long made much of its truly global satellite network and with its new NEXT constellation satellites it has added broadband capability with its Iridium Certus offering.

The satellite and radio spectrum

Both conventional radio and satellite communications receive and transmit electromagnetic signals or radio waves. The length or frequency of radio waves varies tremendously and to distinguish between different lengths of waves they are grouped into bands within the radio spectrum. The bands are named under a number or protocols but in maritime circles, the bands used by the Institute of Electrical and Electronics Engineers (IEEE) are most commonly recognised.

Some bands have a wider spread than others and each of the bands is used for a slightly different purpose. Radio communications on Low Frequency (LF), Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF) and Ultra High Frequency (UHF) bands are all on frequencies below 1GHz which is the lowest point in the spectrum allocated to satellite communications and ship's radar.

When it comes to communications equipment on board a ship, VSAT mostly requires a choice to be made between systems operating on either C-band or Ku-band frequency. Vessels with modest traffic should opt for Ku-band, which requires less power and smaller antennae. Bigger dishes and more power are needed for the larger bandwidth and better quality of C-band systems.

The attraction of VSAT is that whichever band is chosen the equipment usually comes as part of a lease package with a fixed monthly payment, making for greater control over communication expenditure. On many modern ships the operational element of communication use is expanding rapidly, and crews are beginning to expect the kinds of email, internet and calling services that they receive on shore.

Greater bandwidth is now being used to meet the expanding market by making use of the Ka-Band. Inmarsat has invested in five satellites to use Ka-band radio frequencies and deliver mobile broadband speeds of 50Mbps.

L-BAND (1-2 GH)

Almost all of the Inmarsat and all of the Iridium services operate in the part of the radio spectrum labelled as L-band which is very narrow and congested. Being a relatively low frequency, L-band is easier to process, requiring less sophisticated and less expensive RF equipment, and due to a wider beam width, the pointing accuracy of the antenna does not have to be as accurate as the higher bands. Only a small portion (1.3-1.7GHz) of L-Band is allocated to satellite communications on Inmarsat for the Fleet Broadband, Inmarsat-B and C services. L-Band is also used for low earth orbit satellites, military satellites, and terrestrial wireless connections like GSM mobile phones. It is also used as an intermediate frequency for satellite TV where the Ku or Ka band signals are down converted to L-Band at the antenna.

Although the equipment needed for L-Band communications is not expensive in itself, since there is not much bandwidth available in L-band, it is a costly commodity. For this reason, as the usage of data heavy applications has grown, shipping has turned to more sophisticated technology for commercial communications.

S-BAND (2-4 GHZ)

Used for marine radar systems.

C-BAND (4-8 GHZ)

C-band is typically used by large ships and particularly cruise vessels that require uninterrupted, dedicated, always on connectivity as they move from region to region. The ship operators usually lease a segment of satellite bandwidth that is provided to the ships on a full-time basis, providing connections to the Internet, the public telephone networks, and data transmission ashore. C-band is also used for terrestrial microwave links, which can present a problem when vessels come into port and interfere with critical terrestrial links. This has resulted in serious restrictions within 300Km of the coast, requiring terminals to be turned off when coming close to land.

X-BAND (8-12 GHZ)

Used for marine radar systems

KU-BAND (12-18 GHZ)

Ku-Band refers to the lower portion of the K-Band. The “u” comes from a German term referring to “under” whereas the “a” in Ka- Band refers to “above” or the top part of K-Band. Ku-Band is used for most VSAT systems on ships. There is much more bandwidth available in Ku -Band and it is less expensive than C or L-band.

The main disadvantage of Ku-Band is rain fade. The wavelength of rain drops coincides with the wavelength of Ku-Band causing the signal to be attenuated during rain showers. This can be overcome by transmitting using extra power. The pointing accuracy of the antennas need to be much tighter than L-Band Inmarsat terminals, due to narrower beam widths, and consequently the terminals need to be more precise and tend to be more expensive.

Ku band coverage is generally by regional spot beams, covering major land areas with TV reception. VSAT Vessels moving from region to region need to change satellite beams, sometimes with no coverage in between beams. In most instances, the satellite terminals and modems can be programmed to automatically switch beams. VSAT Antenna sizes typically range from a standard 1m to 1.5m in diameter for operation in fringe areas and, more recently, as low as 60cm for spread spectrum operation.

KA-BAND (26.5-40 GHZ)

Ka-Band is an extremely high frequency requiring great pointing accuracy and sophisticated RF equipment. Like Ku-band it is susceptible to rain fade. It is commonly used for high-definition satellite TV. Ka- Band bandwidth is plentiful and once implemented should be quite inexpensive compared to Ku-Band.

Inmarsat was the first to provide a global Ka-Band VSAT service as its GlobalXpress service came on stream in 2016.

The service uses Inmarsat's fifth generation satellites, the first of which arrived on station in 2014 and entered commercial service in July 2014 powering regional Global Xpress services for Europe, the Middle East, Africa and Asia.

As more Ka-Band bandwidth becomes available other satellite providers are offering Ka-Band VSAT on a more regional basis. Telenor Satellite Broadcasting's THOR 7 HTS Ka band payload offers 6-9Gbps throughput with up to 25 simultaneously active spot beams and coverage over the North Sea, the Norwegian Sea, the Red Sea, the Persian Gulf and the Mediterranean. Ka-Sat covers most of Europe. Yahsat 1b, NewSat Australia, Eutelsat and Avanti Communications also provide Middle East coverage, offering mariners with strictly regional European and Middle East sailings a Ka-Band alternative to Global Xpress.

A notable development is that as new services in different bands come on streams, some providers are operating hybrid services that take advantage of the cheapest network at any given time.

The technologies required to facilitate hybrid networks consist of dual-band satellite antennas, Ku and Ka-Band switchable antennas, and the use of equivalent modem/hub infrastructure.

ISM and wi-fi

Most people are familiar with wi-fi as a means for using smart phones and computers and this uses a particular section of the radio spectrum that is actually within the C-Band covered above. There are a number of unlicensed spectrum bands in a variety of areas of the radio spectrum. Often these are referred to as ISM bands - Industrial, Scientific and Medical, and they carry everything from microwave ovens to radio communications. Many of these bands, including the two used for wi-fi are global allocations, although local restrictions may apply for some aspects of their use. The two bands in particular used for wi-fi are the 2.4GHz and 5 GHz bands.

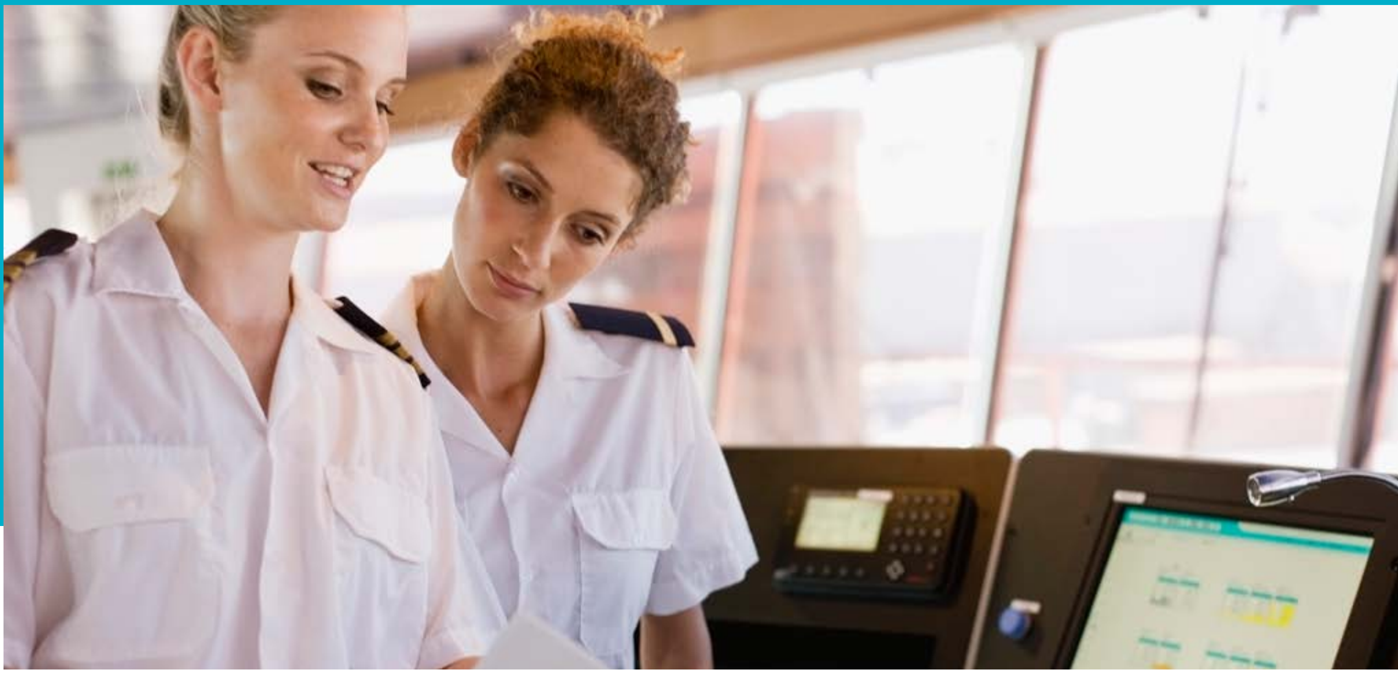
As the 2.4 GHz band became more crowded, many users opted to use the 5 GHz ISM band. This not only provides more spectrum, but it is not as widely used by wi-fi. Many of the 5 GHz wi-fi channels fall outside the accepted ISM unlicensed band and as a result various restrictions are placed on operation at these frequencies.

Over the horizon

While the basics of bandwidth and different orbit types will not change, satellite technology is allowing many new entrants to the market operating smaller but reliable and robust satellites both regionally and globally. Tens or even hundreds of thousands of new satellites are planned, most of which will be in LEO networks.

The technical entry barrier to new players may have been lowered but regulatory restrictions may need to be put in place to ensure that equipment does not present a physical or interference risk to existing networks.

For ship operators a growing choice of services presents a chance to control costs and increase connectivity.



02

GMDSS & regulatory communications

Overview of GMDSS through to 2021 review changes

Regardless of whether or not a ship makes use of modern communications infrastructure and equipment for commercial and welfare reasons, it is obliged to do so for safety purposes under GMDSS (Global Maritime Distress and Safety System) which began in 1992.

Although it did not entirely replace radio, GMDSS was aimed at putting satellite technology at the heart of the safety communications system for maritime users. The advent of GMDSS saw a major change in the way all communications including commercial messages were handled on ships. It also ensured the demise of the dedicated radio officer.

For over ten years a review of the GMDSS infrastructure and system has been taking place at the IMO. The review is now in its final stages after a working group of the NCSR Sub-Committee completed its deliberations in April 2021.

The changes, which include opening up the GMDSS to satellite service providers other than Inmarsat and removing requirements to carry obsolete systems, will require changes to the Safety of Life at Sea Convention (SOLAS). The decision to allow Iridium to operate as a second GMDSS provider is already incorporated into the rules.

This revision of the relevant regulations in SOLAS chapters II-1, III, IV and V and preparation of related and consequential amendments to other existing instruments will now be submitted to the 104th session of the Maritime Safety Committee (MSC), scheduled to meet in October 2021, with a view to approval and subsequent adoption at MSC 105 in 2022 for their entry into force on 1 January 2024.

It is anticipated that all ships communications regulations will be contained in a new dedicated Chapter IV.

Although probably responsible for saving many lives, the maritime communication system that existed prior to GMDSS suffered from a multitude of limitations. GMDSS is an international system that uses land-based and satellite technology and ship-board radio systems to ensure rapid and automated alerting of shore-based communication and rescue authorities, in addition to ships in the immediate vicinity, in the event of a marine distress.

It was adopted by the IMO by way of amendments to SOLAS 1974 Chapter IV in 1988 and entered into force on 1 February 1992 with a phase-in period running until 1 February 1999, depending on ship type and size. With the phase-in period now well past, all ships are now subject to the full GMDSS carriage and maintenance requirements, which vary depending on ship type and area of operation.

The scope of GMDSS and how it operates in practice even in its present form is vast and warrants a complete book in itself in the shape of the IMO-published GMDSS Manual.

Under GMDSS, all oceangoing passenger ships and cargo ships of 300gt and above engaged on all but the shortest of international voyages must be equipped with radio equipment and satellite communications equipment that conforms to international standards.

A survey of GMDSS equipment is needed at regular intervals for the ship to be issued with and retain a valid Safety Radio Certificate. Surveys of radio installation on SOLAS ships should be carried out in accordance with the rules laid down in IMO Res. A.746(18) Survey Guidelines under the harmonised system of survey and certification R 8 (adopted by IMO), and SOLAS 1974 as amended, chapter I, part B.

The radio survey should always be performed by a fully-qualified radio surveyor who has adequate knowledge of the IMO's relevant conventions and associated performance standards and appropriate ITU Radio Regulations. It is considered very important that the responsible radio operators are properly instructed and trained in how to use the GMDSS radio equipment. The radio licence and certificate for the radio operator/ operators should be checked during the survey.

GMDSS operational zones

For the purpose of GMDSS, four operational zones were established, loosely based on distance from shore and in range of different communication systems.

Sea Area A1: the area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC (Digital Selective Calling) alerting is available

Sea Area A2: the area, excluding Sea Area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available

Sea Area A3: the area, excluding Sea Areas A1 and A2, within the coverage of an approved satellite constellation in which continuous alerting is available; and

Sea Area A4: an area outside sea areas A1, A2 and A3.

In practical terms, this means that ships operating exclusively within about 35n-miles from the shore may need to carry only equipment for VHF-DSC communications; those which go beyond this distance, up to about 150 to 400 nautical miles from shore, should carry both VHF-DSC and MF-DSC equipment; while those operating further from the shore but within the footprints of an approved satellite service should additionally carry approved satellite terminal(s). Previously, and until approved Iridium terminals became available in 2021, this has meant that only Inmarsat connected vessels met this requirement.

Sea Area changes post review

As a consequence of the review the sea areas have been redefined as follows;

In the updated SOLAS Chapter IV, sea area A3 will be defined as an area, excluding sea areas A1 and A2, within the coverage of a recognized mobile satellite service supported by a shipboard radio station, in which continuous alerting is available.

Thus, the sea area A3 will vary depending on the type of mobile satellite service:

if Inmarsat is used, the area remains unchanged

if Iridium is used, A3 will become global (merging of the areas A3 and A4)

if a regional satellite system is used (once approved by MSC), the area A3 will be limited to the coverage zone of this system.

There will be no redefinition of the sea area A4, but it will change for different mobile satellite service providers. That means that the sea area A4 will not exist in the case of a mobile satellite provider such as Iridium with global coverage.

Radio rules in coastal waters

Only ships operating in areas A3 and A4 are obliged to carry satellite communications, which means that radios (operating on VHF, HF and MF) are still considered the primary means of communication in emergency situations. In addition, search and rescue transponders (SARTs) and NAVTEX (Navigational Telex) are also required for GMDSS compliance. However, the latter is now considered as obsolete and the requirement will be removed in the revised chapters of SOLAS.

SARTs are devices that are used to locate survival craft or distressed vessels by creating a series of dots on a rescuing ship's X-band radar display. The detection range between these devices and ships, dependent upon the height of the ship's radar mast and the height of the SART, is normally less than about ten miles. Initially only radar SARTS were allowed but since the advent of AIS, a hybrid AIS-SART has been permitted as an alternative.

NAVTEX is an international automated MF direct-printing service for delivery of navigational and meteorological warnings and forecasts, as well as urgent marine safety information to ships.

It was developed to provide a low-cost, simple, and automated means of receiving information aboard ships at sea within approximately 200 nautical miles of shore.
A NAVTEX is usually in a bracket-mounted cabinet with a small LCD screen displaying broadcast messages with an optional printout.

This equipment is now considered as obsolete and the requirement for it will disappear in the revised SOLAS regulations. Some countries may continue to operate NAVTEX warnings and forecasts, but others are likely to migrate the services to satellite communications.

Inmarsat's SafetyNET service is an alternative to NAVTEX for ships that are equipped with satellite GMDSS equipment and provides similar information.

GMDSS Satellite service providers

In the early days of GMDSS, Inmarsat C was the preferred option and minimum requirement where satellite services were mandated. The larger Inmarsat A and B systems were also approved but these were quite expensive and considered as 'overkill' by many shipowners. In 2018, after more than four years of lobbying, Iridium was finally given the green light as an authorised GMDSS supplier at MSC 99 and ending Inmarsat's monopoly on safety service provision.

Current compliant Inmarsat services include Inmarsat B, Inmarsat C, Mini C and Fleet Broadband which was approved in 2018 as a replacement for Fleet 77.

Inmarsat's L-Band satellite network is available in areas A1 to A3 but does not extend to area A4 which is effectively waters in Polar regions. In these areas HF communications are required although vessels equipped with Iridium communication systems can communicate with shore and ship-to-ship providing both vessels have the equipment.

China's BeiDou has also applied for recognition as a GMDSS service provider but this has not yet been granted.

Ensuring GMDSS availability (on ship)

GMDSS regulations define three methods of ensuring availability of GMDSS equipment at sea:

- At-sea electronic maintenance, requiring the carriage of a qualified radio/electronic officer (holding a GMDSS First- or Second-class Radio-Electronics Certificate) and adequate spares and manuals;
- Duplication of certain equipment; or
- Shore-based maintenance

Ships engaged on voyages in sea areas A1 and A2 are required to use at least one of the three maintenance methods outlined above, or a combination as may be approved by their administration. Ships engaged on voyages in sea areas A3 and A4 are required to use at least two of the methods outlined above. The lower requirement for A1 and A2 areas recognises that, being closer to shore, ships will have more opportunity to rectify problems.

The vast majority of ships do not opt for at-sea maintenance, preferring instead to duplicate the equipment and use shore-based maintenance (for A3 ships), or use shore-based maintenance only (A1 and A2 ships).

GMDSS equipment is required to be powered from three sources of supply:

- ship's normal alternators/generators;
- ship's emergency alternator/generator (if fitted); and

- a dedicated radio battery supply. (The batteries are required to have a capacity to power the equipment for 1 hour on ships with an emergency generator and 6 hours on ships not fitted with an emergency generator).

Other regulatory communications

AIS & LRIT

Automatic Identification System (AIS)

AIS consists of a transponder system in which ships continually transmit data over VHF. The data transmitted is derived from ship's equipment as regards position, course and speed, from initial input for the ID, which comprises ship's name and call sign, and from direct manual input for other details such as port of destination and type of cargo.

Updated information is transmitted at regular intervals of very short duration. When received by other ships, the data is decoded and displayed for the officer of the watch, who can view AIS reports from all other AIS-equipped ships within range in graphic and text format. The AIS data may optionally be fed to the ship's integrated navigation systems and radar plotting systems to provide AIS 'tags' for radar targets. It can also be logged to the ship's Voyage Data Recorder (VDR) for playback and future analysis.

In 2000, IMO adopted a new requirement as part of a revised new SOLAS Chapter V for all ships to carry AIS capable of providing information about the ship to other ships and to coastal authorities automatically. The regulation requires AIS to be fitted aboard all ships of 300gt and upwards engaged on international voyages, cargo ships of 500gt and upwards not engaged on international voyages and all passenger ships irrespective of size. The requirement became effective for all ships by 31 December 2004.

The IMO regulation requires ships fitted with AIS to maintain AIS in operation at all times except where international agreements, rules or standards provide for the protection of navigational information. The regulation requires that the AIS must provide information – including the ship's identity, type, position, course, speed, navigational status and other safety related information – automatically to appropriately-equipped shore stations, other ships and aircraft and to receive automatically such information from similarly-fitted ships.

AIS transmitters can also be attached to navigational marks or to hazards and transmit information that will complement the sight/ sound signals that may be present. These fixed AIS transmitters can also be used to give other information such as current strength and direction.

Although initially intended only for navigation use by ships and shore authorities, AIS data is now regularly disseminated by commercial operations either to subscribers or on a gratis basis allowing almost anyone to determine any specific ship's current whereabouts and operational status. The IMO does not condone this use but appears powerless to prevent it.

Because AIS operates on VHF radio, there is a natural limit to the distance over which it can be transmitted.

However, there is a number of service providers using satellites that can receive AIS signals when ships are out of the range of shore stations. These services are generally referred to as satellite AIS or S-AIS. Most of the service providers say that their services are targeted purely at national security organisations, but others make no secret of the fact that their customers are often commercial organisations including commodity traders and analysts.

As the IMO further develops the concept of e-navigation, a potential new technology that is sometimes referred to as 'AIS on steroids' is being explored: VHF Data Exchange System (VDES). VHF had traditionally been used for voice transmission until the advent of AIS and VDES began as a concept developed by the International Association of Lighthouse Authorities' (IALA's) e-NAV Committee. It was originally developed to address emerging indications of overload of the AIS VHF Data Link (VDL) and simultaneously to enable a wider seamless data exchange for the maritime community.

With VDES it will be possible to send broadband data, making it more economical for ships to maintain a data connection at sea by eliminating the need to use satellites in coastal waters, while not compromising on the global connectivity that satellites will be able to provide in the future. VDES is expected to cover up to 50km from the nearest land-based equipment, which will allow ships to benefit from modern communication and navigation methods without increasing costs. VDES is capable of facilitating numerous applications for safety and security of navigation, protection of marine environment, efficiency of shipping and others. Proponents claim it could have a significant beneficial impact on maritime information services including Aids to Navigation and VTS in the future.

Long range identification & tracking (LRIT)

After the use of AIS for reasons of security (rather than its intended aim of an aid to navigation) was found to be inefficient, at MSC 81in 2006 the IMO adopted proposals for long-range tracking and identification (LRIT) of ships, to form part of SOLAS Chapter V.

The obligations of ships to transmit LRIT information and the rights and obligations of SOLAS Contracting Governments and of Search and rescue services to receive LRIT information are established in regulation V/19-1 of SOLAS. Provisions of the amendment came into force in 2009 after which all internationally-trading vessels over 300gt operating outside of GMDSS Sea Areas A1 were required to install the necessary equipment and transmit via satellite technology their identity, location, date and time of position to shoreside bodies authorised to receive it. Ships operating exclusively in coastal Sea Area A1 and fitted with an AIS are exempt.

LRIT requires ships to make regular transmissions of identification and position every six hours to a tracking service which can only release the information with the authority of the vessel's flag state. Other states with an interest in particular ships may make applications to the flag state for access to the information. If security levels are raised, or if a particular ship becomes of special interest, then the regularity of transmissions and monitoring may be stepped up to as much as once every 15 minutes. The operating standards for LRIT demand that the transmissions can be controlled remotely, without intervention on board. Effectively this means that the transmitter must be of a type that can be polled by a service nominated by the flag state.

For most vessels the Inmarsat C GMDSS system is acceptable, as are some SSAS devices. Some Iridium systems are also approved for LRIT compliance. Whatever equipment is used must either have its own in-built GPS system or be connected to an external GPS.

Ship security alert system (SSAS)

Following the terrorist attacks in New York in September 2001, the IMO Diplomatic Conference on Maritime Security held in London in December 2002 adopted several amendments to SOLAS. These amendments include the introduction of Maritime Security in Chapter XI of SOLAS 74 and incorporated the International Ship and Port Facility Security (ISPS) Code which came into effect on 1 July 2004.

As a consequence, all passenger vessels and other ships over 500gt are required to be provided with a ship security alert system (SSAS). The exact type of equipment that can be used to satisfy the regulation is not specified but some operators have chosen to make use of the GMDSS radio station while many others have installed separate and dedicated satellite equipment. By the standards of modern communications technology, SSAS is quite basic, consisting of a GPS receiver linked to a transmitter, a power supply, some software and activation buttons.

Because the technology is simple and the market huge, a sizeable number of manufacturers have come up with SSAS products. They can all be expected to meet the necessary legal obligations but the ways in which they do this vary somewhat.

The principal differences centre on the methods used to transmit the alarm message, but there are also a number of other features and benefits. As an example, some suppliers will act as a co-ordinating centre and when an alert signal is received, they will contact selected personnel of the owner or manager. At least one has developed an app for smart phones that will give all the information to designated persons whenever an alert is made.

Maritime Single Windows (MSW)

Most ships entering or leaving a port are required to obtain clearance from local authorities. Historically this was done by means of paper documents defined under the FAL Convention submitted by local agents and this is still the case in many ports.

The IMO has attempted to make submission of documents automated and performed electronically in the belief that it is more efficient. A mandatory requirement for national governments to introduce electronic information exchange between ships and ports came into effect from 8 April 2019, under the FAL Convention.

The IMO has encouraged the use of the "single window" concept, to enable all the information required by public authorities in connection with the arrival, stay and departure of ships, persons and cargo, to be submitted via a single portal without duplication. The obligation to create systems for the electronic interchange of information established by Standard 1.3bis does not refer specifically to "single window", so the Contracting Governments can use systems other than it to comply with this obligation too.

In June 2021, the FAL Committee issued revised guidelines for setting up a maritime single window that serve as a source of information, advice and guidance for those Member States looking to create a MSW and provides examples of the experience and knowledge gained by some Member States in approaching the implementation of MSW.

As things stand there does not appear to be a universally accepted requirement to use MSWs and very little momentum for their introduction. In most states, port agents are still submitting the data on behalf of ships but there may yet come a time when ships will be submitting the information using their won communication channels.

USCG Notice of Arrival and Departure (NOAD) requirements

After the NY 9/11 terror attacks in 2001, the US authorities became very security conscious. One of the consequences was a requirement by ships to submit information regarding the ship, its crew, cargo and trading history to the US Coast Guard 96 hours before arrival in a US port.

Initially this information could be given by phone, fax or email. Later a dedicated National Vessel Movement Center was established with the possibility to submit the data electronically by way of an e-NOAD.

With many ships' email systems now being managed by software services, the method of submitting e-NOADs can be effectively managed. The NOAD form is a length and complex document, and the use of software can simplify its completion and transmission. GTMailPlus.eNOAD is GTMaritime's software solution for the submission of -NOADs.

Performance monitoring

This is an aspect of communications that is likely to come to the fore as the drive to decarbonise shipping accelerates. There are already two regulatory regimes (one operated for ships regardless of flag calling to EU ports or ships flagged in EU countries and another operated by the IMO) that require ships above 5,000gt to monitor, verify and report fuel consumption and CO2 emissions on an annual basis.

There have been arguments made that this information should be sent more frequently – perhaps as part of ships normal noon reporting – so that more transparent data can be obtained by interested bodies.

Currently there is no requirement for this but some ship operators do take performance monitoring seriously and collate data in real time to monitor fleet and individual ship operations for internal purposes.

IMO regulations, with the possible exception of LRIT reporting, have generally not required ships to make regular reports based on the fact that all relevant information should be recorded in logbooks, by data loggers on certain items of machinery or by the ship's Voyage Data Recorder.

It is always a possibility that with the trend towards more sophisticated communications equipment being installed on ships then at some future point real time reporting of some aspects of operation may be regulated.

Over the horizon

There is a noticeable move by national and international regulators and regional bodies to take greater control of the activities and movements of vessels at sea. This has moved beyond a means of ensuring navigational safety and is now aimed at minimising the perceived environmental impact of shipping.

The impact of some imminent regulation on efficiency and environmental measures may not seem to be directed at communication systems and networks, but if ships are obliged to slow down this will be the case. Assuming global trade remains at current levels or increases, more ships will be needed to transport the same volumes of cargo. This will increase the base load from shipping on the communications network which will need to be met by communication service providers.

03

Commercial communications

Prior to the advent of GMDSS, aside from the short period immediately prior when some ships were equipped with Inmarsat A systems, all communications with ships were done using telegrams and radio telephony.

These were expensive means of communicating so it was common practice for shipping companies to eliminate all but essential commercial communications. Most traffic was done by way of morse code in which every letter has to be transmitted and received individually further adding to the expense. To overcome this, the use of codes such as the Boe Code was adopted. These groups of five letters were used to stand for whole sentences. Some of the five letter groupings were standard chartering and shipping terms and others were encrypted and only decipherable by the shipowner concerned.

The practice of coding and communicating in this way is now obsolete although it has parallels with compression and encryption of electronic messaging today but without the need for the sender or receiver of the message to go to the trouble of coding and decoding the message.

As the cost of communicating has fallen, many ship operators and managers have embraced the opportunity to communicate more freely and the volume of traffic has definitely increased dramatically and is still accelerating.

Having said that, the volume and method of communication will be determined by the type and age of the vessel and the service it is operating on, and the ship management strategies and procedures of the ship operator and cargo owners.

Commercial communications can be split into two main categories: those concerned with the employment of the vessel (Voyage related communications) and those related to management of the vessel (operational communications).

In the first category will come matters such as voyage instructions, notices of arrival contact with ports, agents and cargo interests. Ship operational communications will revolve around ISM and safety management, stores and supplies, crew changes, and increasingly performance monitoring, monitoring of equipment and perhaps an Internet of Things as ships become more connected.

Voyage related communications

Ships operating on spot markets generally have very little need for anything other than basic communications in regard to the employment aspect. Voyage instructions will be given by the owner or the time charterer and are usually confined to a brief resume of the final fixture terms along with agents' contact details. Those familiar with broking practices will know that here the use of standardised abbreviations is the norm and all necessary details can be contained in just a few lines of text.

Armed with details of the next voyage, the master only needs to send arrival notices to the load port agent at prescribed intervals. He may also ask for a shipchandler to attend or for the agent to arrange medical facilities or some other need of the vessel. Large vessels that undertake long voyages may only complete a handful of voyages annually and may even be on a consecutive voyage contract so will not even need the fixture details for each voyage.

Ships that operate in the short sea markets will make far more voyages and so have a higher communications requirement. That said, many will be operating for much of the time in range of mobile phone coverage and some companies prefer to make use of this medium for communications whenever convenient.

Passenger vessels other than ferries operating on day services, will also need to keep port agents advised of arrival times and to request stores and other services. Depending upon the ports being visited there may also be a requirement to send passenger lists to the port agent or immigration authorities although frequently this will be taken care of by the shore offices of the shipowner.

Other non-cargo ships such as cable layers, offshore vessels, seismic survey and research ships will need to keep owners and charterers advised of positions and port agents advised of needs.

Communication between ships and service providers such as pilots and tugs is mostly done over VHF radio.

Container monitoring at sea

Liner vessels, which carry many thousands of containers have surprisingly few voyage related communications with ports and service providers outside of the company as much of the work is done by port agents. That said, there is a pent-up demand from shippers and receivers of cargo to have more regular information about conditions on board especially where reefer containers are concerned.

With reefer containers, crew must take regular readings of temperatures and monitor the boxes for malfunctions. Reporting as necessary any untoward events. There are some IoT systems in operation which automate this process using sensors in each container that transmit to a hub onboard which in turn transfers data by satellite. The information is then accessible by the crew as well as by the ship operator and potentially also the cargo owner. Depending upon the ship's route and number of transhipments to shore and other vessels, there may be times when the information is not available but over time these gaps will likely be eliminated as more ports and vessels are connected.

Container vessels also have rather complicated stowing requirements necessitated by different kinds of hazardous cargo being carried and the port rotations. Because ships rarely discharge only or load only at each port, containers will be both discharged and loaded which sometimes means that boxes have to be moved onboard to permit safe carriage of newly loaded cargo.

Planning the stowage of container ships was difficult enough when ships were small but with modern vessels carrying several thousands of boxes the permutations are of another magnitude. Most stowage plans are now made by computers and that information needs to be shared and monitored by the shore offices, ships and ports. This can generate a lot of data and so places a high load on ships' communication needs.

There is a move from the major liner operators including A.P. Moller – Maersk, CMA CGM, Hapag-Lloyd, MSC and Ocean Network Express to develop standardised information requirements in the container and logistics sectors. These common information technology standards will be made openly available, free of charge, to all stakeholders of the wider container shipping industry via a neutral non-profit body. The increasing volume of cargo-related communication requirements has been a major driver in leading container operators making use of VSAT communications.

Operational communications

This is an area where probably much more information flows between ship and shore office than does with voyage related communications. But there is a marked divide between small and large operating companies. It may be a surprise, but the average shipping company has only around 10 ships in its fleet. Considering the major companies have fleets running into hundreds of vessels, it suggests that many companies have just one or two ships in operation.

In addition, many of the tens of thousands of ships in the world fleet are engaged on domestic trade routes, often returning to their home port each day. For such ships, the communications requirement is frequently limited to emergency needs only and is covered by GMDSS regulations.

In the larger fleets and especially those with newer equipment, there will be a great deal of monitoring systems employed – notably on the main engines. The company Safety Management System required under ISM rules will be complex and may involve a requirement for regular safety reports and bulletins as problems arising on one ship are advised to others to allow appropriate action.

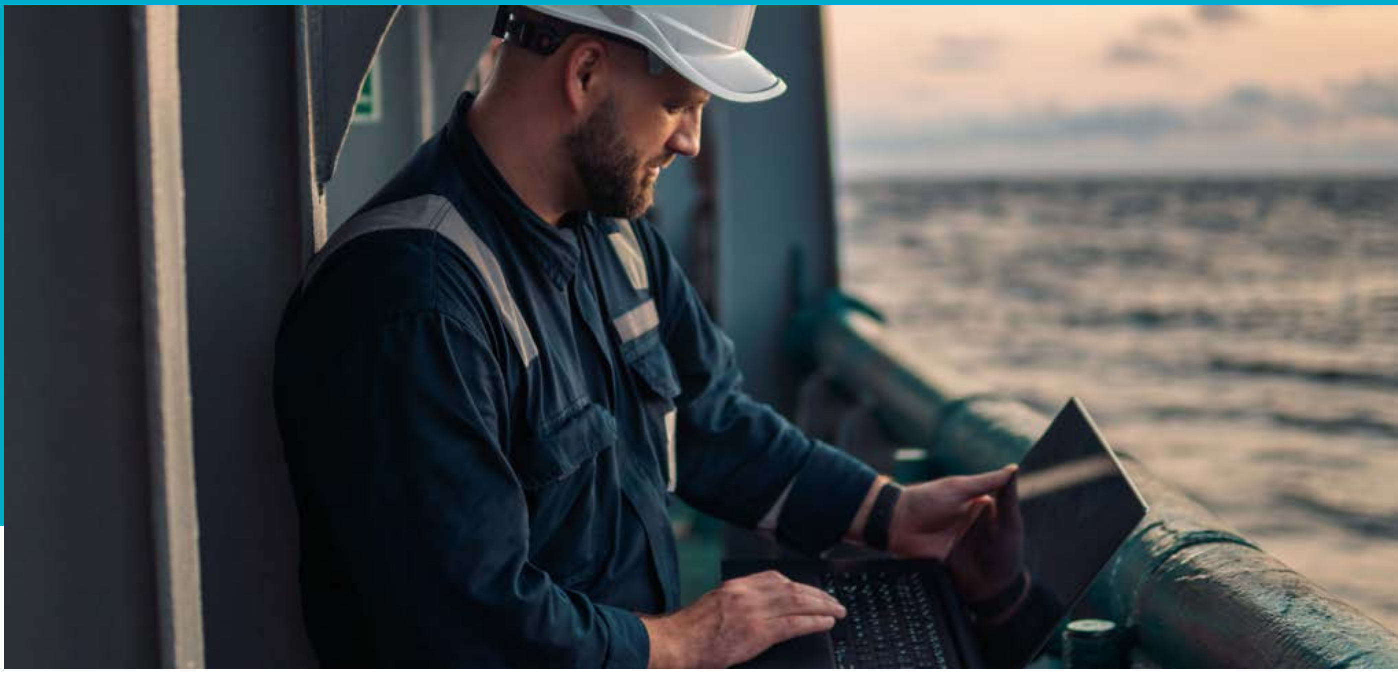
The communications needs for these companies are very large and once again will require more bandwidth to transfer the data generated. The larger fleets are also those most likely to have a crew communications policy that allows crew to make private communications. As the data flow increases so does the need to manage and prioritise communications. There are many systems that can do this either provided by the communications service provider or by a third party.

These systems are able to schedule routine communications to quiet periods and to be able to recognise different communication methods at times of high traffic and so prioritise according to user or application in use. Such systems are especially useful on ships which have large numbers of crew and supernumeraries on board such as offshore vessels, passenger ships, research vessels and the like.

Over the horizon

Shipping is a constantly evolving industry with many segments having different requirements. Increased accessibility to communication networks and reduced costs will inevitably change the pace at which the industry embraces digitalisation but some segments will move faster than others.

The COVID pandemic has been a cause of many societal changes which will gradually permeate into shipping and bring a need or desire for increased communication. There is a discernible trend towards VSAT in recent years indicating a desire for more bandwidth. How this will be impacted by an expansion of the physical space when 6G and 7G networks roll out is matter for debate.



04

Crew & passengers

Over the years since GMDSS was introduced communication use on ships has undergone a revolution. The surge in satellite communication equipment sales that resulted was enough to convince service providers that there was a rich vein to be tapped with growth coming from outside the traditional traffic that passes between ship and shore.

When the digitalisation of shipping was not even a consideration, the one that attracted the most attention was crew calling. Ever since It has been promoted both as an essential element of crew welfare and as a means of retaining staff in a time of shortage of skilled seafarers.

That argument is generally accepted but as access has improved and more modern technology that has allowed internet access as well as telephone calls has been installed there have been some negative comments. One is that some seafarers, able to use the internet for gaming, browsing and social media, are tending to isolate themselves from colleagues to the detriment of cohesive teamwork on the ship.It should also be pointed out that in at least three casualty investigations by the UK's MAIB, use of personal communications equipment causing distraction has been mentioned as a contributing factor to a grounding or collision.

Access for crew to communications is by no means universal. Take up has been high in some sectors especially in the offshore and among higher quality operators.

Probably up to half of the vessels sailing have no provision for mobile telephone or internet connectivity for crew whatsoever beyond what the crew can provide for themselves. A very small number of frugal owners may feel that they have good reason not to provide crews with the means to report poor conditions on board.

Crew calling on the ships that adopted it early usually involved the operator providing a telephone or a computer terminal for email connectivity that crew can use during non-working periods. Some operators may provide a free of charge service but more commonly crew members are charged for their communications usage either through a prepaid card or by deduction from wages. Logging on to the systems is usually by assigned passwords so as to allow the operator to identify actual usage.

On smaller vessels and those with little more communications equipment than is mandatory, providing crew calling can create difficulty. With perhaps only one telephone on board for crew calling, disputes may arise over usage while seafarers whose families lack a home telephone or computer (quite rare today but not unheard of) will have no need of the service. Where access to communications is limited, ratings generally fare worse than officers.

Crew communications and connectivity is partially in the 2006 Maritime Labour Convention. Although there is no specific mention of provision in the mandatory part of the convention text, there is reference in the guidelines. Guideline B 3.1.11 Section 4 lists facilities that should be given at no cost to the seafarer where practical. Item J in this text covers 'reasonable access to ship to shore telephone communications and email and Internet facilities where available, with any charges for the use of these services being reasonable in amount'. Exactly how this guideline is interpreted and put into operation by flag States and ship operators is not widely publicised, but it does at least open up the door to wider access for seafarers in future.

Since the early days of crew communications, communication service providers have been rolling out new products to take advantage of increased access by crews. Today this normally takes the form of the dedicated terminal being omitted in favour of crew using their own cell phones, tablets or computers with some form of control system and software monitoring individual use. Depending upon the ship type there are at least two ways of doing this.

One is an extension of the systems now commonly found on passenger ships equipped with VSAT where the ship is assigned its own unique roaming identification and passengers and crew can use their own personal mobile phones with the cost charged to their new normal billing system. A variation on this allows the crew members to use their own phones but with a different prepaid SIM card fitted. With the different cards crew can take advantage of special great calls between similarly equipped phones even when the users may be on a different vessel.

Another method is by means of picocells connected to the ships communication system. A picocell is a small base station installed in accommodation areas of the ship that extends mobile coverage. Connected to a remote gateway it will convert a mobile call into a narrowband IP signal for transmission over the satellite network used by the vessel. The picocells allow mobile phones fitted with appropriate prepaid SIM cards to access the communications be they VSAT or L-Band. If a VSAT connection is available, it would be possible to assign roaming rights that allow crew to use their own phones.

Wherever prepaid SIM cards are used, a crew member will need to use a mobile phone that has been unlocked. When in port and away from the ship the user can still use the phone once the prepaid SIM has been replaced by one obtained locally through a local or international service provider. If a phone has a dual sim slot this makes switching even easier.

Determining the full extent of crew access is not easy and relies on surveys carried out by interested parties. There have been no published surveys during the last two years when seafarers arguably had a greater need for communications than at any time in the past.

A survey carried out in 2017 by the seafarers' trade union Nautilus International, which represents more than 22,000 maritime professionals mostly from the UK and the Netherlands, showed that although 88% of seafarers now have some sort of internet access, only 6% can video-call families. By comparison, statistics at that time show 91% of UK homes and 85% of European homes have broadband access, with the United Nations recently suggesting that access to the internet should be a basic right, rather than a luxury. The Nautilus survey interviewed nearly 2,000 seafarers and shipping industry leaders for the research.

Other key findings showed that although most seafarers have internet access, they are on limited wi-fi speeds at a high cost. In addition, only 57% of crew have personal email access and just one third have social media access at sea (34%).

More than 80% of Nautilus' members who completed the survey considered communications one of the most important collective bargaining issues, second only to improved pay. Nearly two-thirds of respondents (63%) agreed they would consider moving to a shipping company that offered better onboard connectivity.

Of the industry leaders surveyed, more than one in 10 (14%) admitted they do not provide their employees with any access to the internet. The two biggest reasons given were fears crews would access illegal or adult content (83%) and the potentially high installation costs (83%). The survey also found that nearly two-thirds of respondents (58%) were concerned the provision would result in a distraction to work.

Another survey was carried out in 2018 by Futurenautics in association with KVH and Intelsat. This survey is the latest in a series going back to 2012. Key findings of the 2018 survey show some similarities with the Nautilus International Report. According to the report, 75% of vessels have internet access but just 61% of seafarers have access to crew communications services 'most of the time' or 'always' but the rest (650,000 seafarers, the report says) "still struggle to stay connected whilst at sea", including "below 2%" of the total never having access to crew communications. That works out at about 32,000 seafarers.

For ship operators to allow crewmembers access to communications and to recover the cost either by selling prepaid cards or deductions from wages is one thing and leaves them in a breakeven situation. For the seafarers the cost of communications is still a big issue. In the early days a voice phone call would cost as much as US$0.53 per minute – maybe not a huge cost for an offshore vessel crew member but very much so for the average AB on a cargo vessel.

The 2018 Futurenautics study revealed seafarers worldwide are spending, on average, between US$89.46 (seafarers from Europe, the Middle East and Africa) and US$132.13 (south central Asia) on communication whilst at sea. As of 1 January 2016, the International Labour Organisation (ILO) stated that the basic monthly wage for an AB was US$614. Their communication costs are therefore a very high percentage of wages – some may consider too high a percentage especially if the seafarer has a family to care for.

For shipowners some benefits are to be had from fast connections on passenger vessels such as cruise ships and ferries. Here an extra revenue stream can be tapped by allowing passengers to use their own mobile telephones onboard. Both passengers and crew can benefit from streamed entertainment services of which there are an increasing number.

Services such as Inmarsat's Fleet Media allow for latest movies, international films, sports and TV shows to be downloaded on vessels anywhere in the world. This gives crew members access to hundreds of hours of on-demand content that can be watched on a laptop, computer or an iOS or Android smart device via wi-fi or physical network connection.

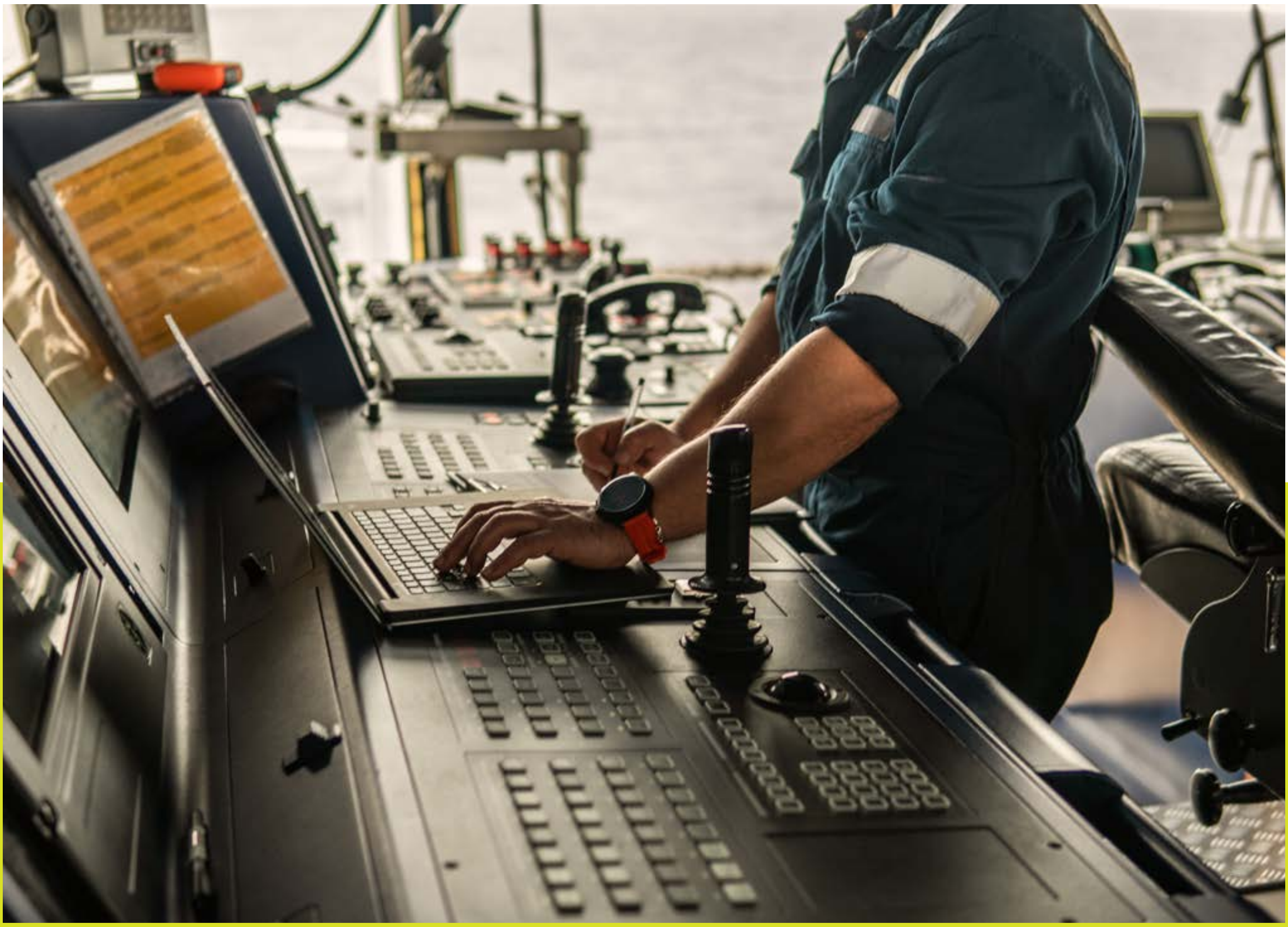
The Nautilus survey results were announced in July 2017 but had probably been compiled some time earlier. By coincidence the cyberattack experienced by Maersk Line, which caused it to replace every computer within the company took place in June 2017. Ever since the question of cyber security and the vulnerabilities of systems has constantly raised the issue of crew communications being a possible weak point that needs addressing.

Security was not really an issue when crew communications first took off because the mobile phones then were generally not able to do anything beyond making voice calls and SMS messages. Even when the first iPhones appeared in 2007, their price tag was beyond most seafarers.

The issue of cybersecurity will be covered in a future article, but it is a convenient point to highlight that separating crew/passenger and ship's communication networks is perhaps a sensible precaution given that cyber threats are more likely to come from emails and personal communication given the lack of controls that are usually exercised.

Over the horizon

Looking ahead it is inevitable that more advanced and compact systems will be developed that will reduce costs and enhance connectivity. This will mean that data volumes will increase but there would not appear to be a capacity issue limiting this growth. An increasing number of satellites are planned to be launched including many in LEO constellations by new players in the market. This would seem to present the ideal opportunity for ships to install more systems onboard allowing separation of systems for security while providing redundancy.



Section 02

The connected ship

05

Performance monitoring

Performance monitoring is a relatively new development in ship operation that has its origins in the trim optimisation software developed by several companies in the mid-2000s. At that point in time, the ability to transfer large volumes of data ashore was something that most ships did not have so the software systems on the market were aimed at giving crew on board information that could be actioned in real time or used for improving future operations.

Initial reaction to the systems on offer was mixed. While generally welcomed by less experienced officers and shore staff who would have eventual access to records to analyse, more experienced navigators sometimes felt their skills and experience gained over years at sea were somehow being undermined.

The developers of these systems were mostly ex-seafarers themselves and understood that trim optimisation – keeping the vessel on as near an even keel as possible given cargo, fuel and ballast conditions along with prevailing sea and weather – was key to reducing fuel use under all weather and vessel loading conditions.

The market place was very soon becoming crowded with the likes of Eniram, acquired in 2016 by Wärtsilä and now assimilated into the Wärtsilä Voyage division, Kyma, Marorka, Force and GreenSteam being just some of the early pioneers. As examples of the benefits of digitalisation, these systems are definitely among the front runners and have been great demonstrators of how simple data can be used to very good effect.

Whilst all of the systems have their own unique differences, basically all collect a wide range of real time measurements such as inclination of the ship both fore and aft and transversally, ship speed, engine power and load, fuel use, wind and tide strength and direction, capacity of ballast, fuel and other easily moved stores.

With the data acquired, the software can rapidly calculate all of the possible permutations and present the information for the crew to take any necessary remedial action. Most of the systems can also make recommendations or show the effect of a possible change in one of the parameters. For example, a change in speed, engine load or course direction.

Even as stand alone systems on board individual ships, these systems did produce some significant fuel savings but improvements in the software and growing use of communications would mean they could develop into full performance monitoring solutions for the shipowner.

Initially, most of the owners that wanted to take the next step were content with receiving accumulated data from ships at regular intervals which could be analysed at leisure and where considered necessary new working procedures and instructions sent to ships. However, it was not long before the software developers had enhanced and upgraded their products to allow transmission in real time with fleet and online versions. Options included direct transmission to a shore office or a cloud-based reporting system that allowed personnel to access from anywhere at any time.

The spread of sensors and data collected has expanded to cover many more aspects. For example, the Marorka Onboard system can use computer models of the ship's hull and energy systems for monitoring the efficiency of electricity production and consumption as well as the overall efficiency of the on-board electrical grid; Improving the efficiency of electrical power production and consumption by managing generator loads and reducing unnecessary use of electricity; Providing specialised analysis and advisory support for increasing the energy management of individual systems such as: waste heat recovery processes, cargo pumps and refrigeration.

As far as fuel is concerned, the Marorka system can monitor which type of fuel is being used and relate it to areas of trading. It also details simultaneous consumption by different users. Consumption balance monitoring and registration of discrepancies between reported fuel additions and measured fuel consumption can identify leaks from tanks or fuels lines.

Depending upon the ships systems and equipment suppliers, data can be assimilated from virtually anywhere giving a full picture for the ship and shore office. The information can provide early warning of equipment failure and also identify when a ship may be approaching the limits of performance and consumption limits set out in charter parties.

The online modules that can be integrated into most systems automatically transfer data to shore and can even simultaneously display data from a whole fleet on a large office display so that any ship which is not performing optimally at that moment can be identified.

Several of the systems can be programmed to identify operating profiles on regularly used routes that minimise fuel use and modify these based on changing weather and sea state forecasts.

The field of performance monitoring is not limited to specialist software providers with companies such as ABB with its ABB Ability Tekomar XPERT family of products and Kongsberg's Vessel Insight systems taking advantage of the experience of those companies in providing engine management systems.

Most performance optimisation products take into account fuel consumption and variables related to outside influences but do not link in any way to the engine management. Thus, an opportunity to improve efficiency is missed. Digitalisation at the engine level already provides services such as predictive maintenance. However, it can also provide instant, in-depth analysis of the engine with real time advice which can be implemented to reduce fuel consumption. This can ensure the engine is operating at maximum performance and help extend the lifetime of the engine by monitoring asset health.

There are many factors that can increase fuel consumption and although the data is being collected and recorded regularly, small changes that make performance sub-optimal can go unnoticed until they reach pre-set levels that trigger warnings. For example, a drop in scavenge air pressure could be caused by something as simple as a clogged turbocharger filter and a reduction in turbocharger efficiency caused by worn nozzle rings. The deterioration will be gradual in the same way as fouling growth on the hull increases drag and causes a rise in fuel consumption.

The latest trend in performance monitoring involves its evolution into what is often called an Internet of Things (IoT). This is being enabled by communications services providers actively encouraging the use of third party applications on their platforms. An example is Inmarsat's Fleet Data solution. This is a bandwidth-inclusive IoT platform that allows ship operators to instantly collect data from onboard sensors, upload the data to a secure cloud-based platform, and interface with applications from third-party application developers.

Over the horizon

Quite clearly, expanding into new areas of ship systems and transmitting data will increase the load on the communications systems but with the level of fuel savings that are being reported, it is likely that the extra cost of communications will be covered many times over and at the same time allow capacity for further changes such as assisted maintenance or remote operation.

06

Remote operation and assistance

This is a subject that has its roots in numerous places; the controversial concept of autonomous ships, the idea that 80% of maritime incidents are caused by human error, the trend for reducing crew numbers and as a reaction to incidents such as the grounding of the Costa Concordia.

Remote operation is seen by some as a halfway step to autonomous ships but by others it is making use of technology to assist the crew of the vessel in emergencies and by providing back up under other circumstances.

The idea of autonomous ships may have been something discussed in military circles and in boardrooms of commercial equipment suppliers, but it was never really a topic that ship operators themselves had publicly debated prior to 2012 or thereabouts.

The related concept of e-Navigation was however at the heart of the EU's ATOMOS (Advanced Technology for Optimising Manpower On Ships) project begun in 1992. The aim of this project was to reduce crew numbers on EU member state flagged vessels as a response to the lower crew costs for Asian and East European shipowners being seen as a threat to competition. One of the conclusions of the project was that modern low-manning, high-tech ships are at least as safe as conventional vessels.

In 2012, another EU funded project MUNIN (Maritime Unmanned Navigation through Intelligence in Networks) was purely concerned with developing autonomous and unmanned ships. The project completed in 2015 by which time the subject was being openly discussed and debated throughout the shipping industry.

The timing of the MUNIN project may have been coincidental but it followed rather quickly on from the grounding of the Costa Concordia in January that year. The vessel had deviated from its planned route at Isola del Giglio by direction of its captain and struck a rock formation on the seafloor. The tragedy, in which 32 people died, raised questions about the attitude of ship operators and their lack of oversight of vessels at sea and led directly to some companies including the Carnival Group to establish shore operation centres.

The matter of fully unmanned autonomous ships is still a matter or debate and while there are some projects in place, the regulatory and commercial desirability is a long way from being decided. Remote control of ships is however now a reality although not yet at a commercial operation level.

In 2017, Rolls-Royce in conjunction with tug operator Svitzer demonstrated the world's first remotely operated commercial vessel in Copenhagen, the 28m long Svitzer Hermod. From the quayside in Copenhagen harbour the vessel's captain, stationed at the vessel's remote base at Svitzer headquarters, berthed the vessel alongside the quay, undocked, turned 360°, and piloted it to the Svitzer HQ, before docking again.

The tug is equipped with a Rolls-Royce Dynamic Positioning System, which was the key link to the remote controlled system. The vessel also features a range of sensors which combine different data inputs using advanced software to give the captain an enhanced understanding of the vessel and its surroundings. The data was transmitted to the remote operating centre which was designed to redefine the way in which vessels are controlled. Instead of copying existing wheelhouse design, input from experienced captains was used to place the different system components in the optimum place to give the master confidence and control. The aim was to create a future proof standard for the control of vessels remotely.

Later the same year, a team from Wärtsilä Dynamic Positioning remotely controlled a platform supply vessel in the North Sea off Scotland using a standard satellite link from its office in California 8,000km away. The satellite link included no significant latency and allowed for manoeuvring the vessel as if aboard the vessel. To make the remote control work Wärtsilä said the greatest challenge was developing a way to get sufficient data over a low-bandwidth connection but did not reveal how this was achieved. The team also needed to find a way to recover the link seamlessly if it was disrupted, and to make it secure to counter the risk of hacking.

The vessel was a 4,000dwt, 80m PSV. The control system used at the remote centre was an identical model of the ship's integrated bridge system. Over the course of four hours the Wärtsilä team used the Gulfmark Highland Chieftain's DP system to send it on a 'box manoeuvre', 20m in four directions. They then used a combination of DP and joystick control to carry out a series of other manoeuvres, testing control of surge, sway and yaw, before steering the vessel for a short distance on its journey back to Aberdeen.

In both cases, a normal crew was on board in case of problems developing, but in neither case did they have to intervene.

After the test, Wärtsilä said in a statement that the big prize in the short term is to use remote control technology to move some crew onshore, rather than to develop a completely unmanned ship.

To do this, Wärtsilä is looking at using video and laser proximity sensors to allow the remote operator to have the same situational awareness as an officer on the bridge. The company did not believe this was possible with the satellite links then available but said ships could switch to 4G near the coast, so offshore crew can navigate through traffic, around obstacles, and into ports. Some degree of autonomous control will also be crucial so that the ship knows what to do if the connection is lost.

In 2020 Samsung Heavy Industries navigated a tug from a remote operations centre 150 miles away from the port. The demonstration combined collision avoidance, autopilot, and remote control technologies. The 125-foot tug operating at the Geoje Shipyard in Korea was outfitted with the company's Samsung Autonomous Ship technology.

According to Samsung, SAS analyses in real-time signals from navigational communication equipment, including radar, GPS, and AIS, to recognize nearby ships and obstacles. The system develops the route for the vessel, evaluating the risk of collision considering the ship's operating characteristics. It then navigates the vessel to its destination by automatically controlling the propulsion and steering.

Operators at the remote control centre were able to monitor the operations and guide the vessel with images combined with augmented reality (AR) technology. Among the tools they had was a 360-degree view around the ship that was made possible using LTE/5G mobile communication technology. At the land control centre, they viewed the images on a large screen, monitoring the operation of the ship and demonstrating the technology to directly control the tug.

Projects involving remote control as a prelude to autonomous ship operation are also underway around the globe. One of the most ambitious was to send an autonomous craft across the Atlantic. The Mayflower Autonomous Ship project has its own website (MAS400.com) from where developments can be tracked. The trimaran vessel which is around 30m began its planned voyage in June 2020 but was forced to turn back with a mechanical problem two days into the voyage. After repairs it was put back in the water in September 2020 but the planned voyage was postponed until early 2022. With no humans onboard, the research vessel uses IBM's automation, AI and edge computing technologies to make decisions based on its status, environment and mission.

Remote assistance

The criticisms levelled against shipping after Costa Concordia galvanized some operators to establish better oversight of vessels at sea. Carnival Corporation – the parent of Costa Cruises – has been a pioneer in this respect and has established three Fleet Operation Centers (FOCs) in Hamburg (2016), Seattle (2017) and Miami (2018).

The FOC monitors all aspects of navigational safety, weather and energy management. It receives screen shot data from the bridges and engine rooms, all ships being monitored every 60 seconds and can switch to 15 second feeds if necessary. In addition, alarm status, stability information, and tank status is also transmitted. The information is displayed on a wall mounted screen display comprising several large screens allowing all relevant data and equipment status to be viewed with the need to switch screens as is necessary even on some bridge workstations which only have a single screen.

The centres are manned 24/7 always with at least two experienced mariners on hand. In the event of any safety concerns, the FOC team supports the captain and his crew on the vessel concerned. The FOC also supports the ships with regard to any non-safety-critical situations deviating from planning, such as developing gales or hurricanes which could make route alterations necessary, rescheduled sailings due to the late arrival of embarking passengers, etc.

In case a navigating ship deviates from the planned route corridor, the FOC staff receives an alert. In such cases it verifies if the deviation is comprehensible and its cause, which might be dense traffic (confirmed by reference to screen shots from radar, AIS etc). If the cause of the deviation cannot be verified, the FOC makes immediate phone contact with the ship. In a developing situation, the ship itself can make contact with the FOC seeking advice.

Collection of automated data done through the Microsoft-based 'NEPTUNE' platform, specifically developed for use by Carnival Maritime, allows for storing and comparing of the data of all ships monitored and supported, helping to define best-practice solutions for example for itinerary planning or engine usage on a specific route.

Carnival has built custom tools for use and integration into the FOCs such as its proprietary software applications Neptune and Argos. Developed in-house, Argos is an always-on knowledge management tool that harnesses information from thousands of data points and overlays rules-based decision making, predictive alerting and queuing into one visual dashboard. The result is at-a-glance situational awareness across the fleet which significantly improves communication from ship to shore, enhances safe passage of ships, improves operational efficiencies and supports overall environmental initiatives.

Neptune captures and provides analytics for dozens of distinct parameters for navigational safety from each ship, focusing on three strategic areas to optimize safety, efficiency and overall fleet performance.

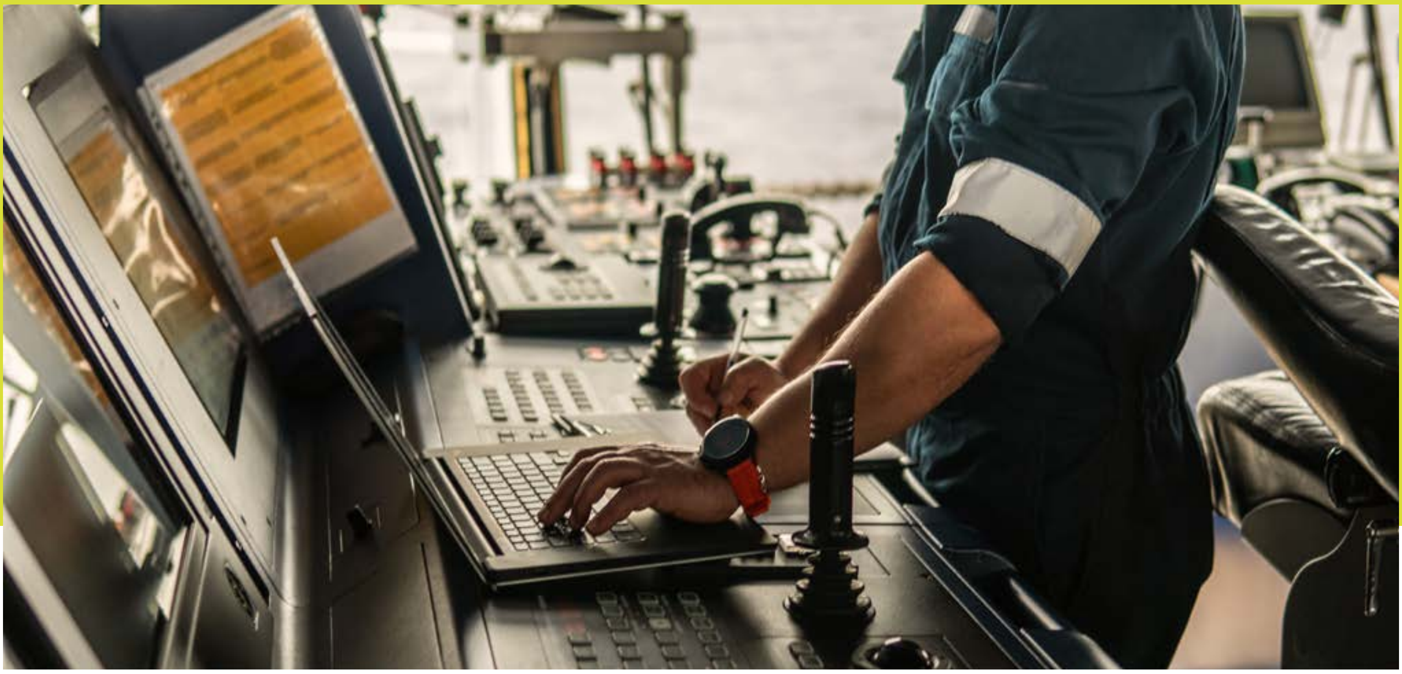
Carnival is not the only company to operate such centres but to build three or more which can each take over if one centre goes offline for any reason is probably beyond the reach of many operators especially as Carnival's network is built upon the company's structure with offices for its different fleet areas.

Over the horizon

Assuming the commercial objections can be addressed, at some point it is likely there will be a fusion of the remote control centres used in the few projects that have taken place and the FOCs of operators such as Carnival. Just as the crew on board the remotely operated vessels were there to step in if the remote trial went wrong, so the staff at FOCs could do the same under exceptional circumstances. That could include the illness or death of key officers or even an event such as a pirate attack.

As things stand, there are very few systems on ships that could reliably run for long periods without crew intervention. In some ships for example, the emergency steering gear operates using manpower. Autonomous ships will therefore need to be less complex than current vessels, this could happen with new propulsion technology but that is not yet mature enough for immediate deployment. Even with unmanned ships, there will be a need for trained seafarers able to operate the ships remotely and to understand the intentions of other ships. Fully autonomous ships should only need human intervention in emergencies, but unexpected problems can arise at any time.

Most important will be the communication link between ship and shore. There must be abundant bandwidth and a failsafe system in place to fall back if a comms link is broken or a remote operation centre is hit by a power outage for example.



07

VR, AI & new maintenance methods

Historically equipment makers have recommended maintenance regimes for their products. In the early years after sale, following the recommendations are essential to meet warranty requirements. After that most operators have tended to follow the OEM's recommendations and use a preventative maintenance strategy that requires replacement of parts at specified intervals.

More recently there has been growing acceptance of condition based or predictive maintenance regimes. In these there is a reliance on testing of lubricants for signs of component wear and more measurement using sensors for parameters such as heat, pressure, temperature or vibration.

Ships are a complex mix of machinery and equipment systems and although some are unique to ships, many have equivalents on shore. First and foremost among these are the engines, especially medium-speed, four-stroke engines. On ships these can be either propulsion engines or gensets and a similar situation exists onshore where they are used in power generation or in road and rail transport.

For decades it has been common practice in shore situations for the engine maker to be heavily involved in maintenance of their equipment in power stations. In some cases, the power station operator may even contract with the engine maker to provide all the staff necessary to routinely operate the engine. With the development of electronic engine management this has accelerated the use of condition based maintenance regimes.

This has been taken a step further still because the more robust communication facilities available on shore have allowed equipment to be monitored around the clock from central control stations and the computerised engine control units can be modified remotely to adjust engine running parameters or even to stop an engine if a dangerous situation develops.

These developments are gradually finding their way into the marine sector but restricted communications on many ships combined with the fact that equipment on older vessels may not be suitable for some of the changes that are becoming possible. Almost all engines installed on ships today will be electronically controlled and have an engine control unit and some older engines can be upgraded.

In order to switch from a preventative maintenance regime to a condition based regimes, historic data (which may be paper-based) needs to be collated and recorded after which new data will be added either in real time if communication systems allow or at regular pre-determined intervals. If the shipowner chooses an OEM's maintenance service, then the data can also be used along with data from other operator's engines to build a database for each engine type which can help with trend analysis using AI and algorithms based on multiple recorded faults.

Unlike shore-based engines which are usually standard models, marine engines can often be one-offs particularly in the two-stroke arena. Even seemingly identical engines may have differences if built by different licensees who are able to make some of their own modifications. This can make building databases difficult but even if the quantity of data is small, it can be used to predict some problems.

Although the majority of shipowners moving to condition based maintenance tend to use the services offered by OEMs, there are a growing number of third party providers in the market. A ship operator with multiple engine brands across its fleet may prefer to use such a service for a whole variety of reasons including – but not limited to – cost.

Shipping is not being left behind in other aspects of maintenance and training. Both of the main engine makers (MAN Energy Solutions and Wärtsilä) have embraced VR training and added it to simulator training and hands on training services. This does permit engineers to be trained on products that are not physically present and has potential for use onboard ships as well as in training establishments.

It is however in the field of remote assistance enabled by augmented reality that the greatest potential for onboard use is to be found. In early 2019, Wärtsilä successfully tested its remote guidance service that it plans to roll out to customers making use of the Pointr App that can run on mobile phones and tablets.

The tests were conducted in real time using voice-controlled Augmented Reality (AR) wearables and remote guidance software, onboard the Huckleberry Finn, a ro-ro ferry operated by TT-Lines, while sailing between Trelleborg, Sweden and Travemünde, Germany.

Simulated remote guidance service situations were carried out on the ship's navigation equipment on the bridge and on the shaftline seals and bearings in the engine room.

The Wi-Fi signal for the video sessions was facilitated by a portable on-deck LTE antenna. The onboard simulations were monitored in real-time by expert Wärtsilä personnel located in Gothenburg and Hamburg. The tests verified the effectiveness of the AR wearables as a means of communication, while the portable Wi-Fi antenna provided a strong signal wherever needed.

Wärtsilä's remote guidance service also proved successful during a demonstration in the TT-Lines office, during which remote guidance opportunities for use in dockings and shipyard overhauls were discussed.

Some months after the Wärtsilä tests ABB which manufactures turbochargers, motors and propulsion systems also began introducing AR functionality for its service teams and client contractors and engineers.

ABB's Ability Remote Insights service will give field service technicians an AR interface that includes remote guidance, screen sharing, and document sharing to guide them through performing specific tasks. ABB says in addition to improving the performance of technicians working in remote locations in terms of speed and efficiency, the system will improve response times and extend asset lifecycles.

ABB supplies AR software but hardware is left as a choice for the user. Ideally this should be an AR or mixed reality headset such as the Hololens, Google Glass Enterprise, or Vuzix AR glasses as the user will have both hands free for working and to use hand gesture controls to navigate the Remote Insights interface. ABB says the system can also work on smartphones, tablets, or other wearables.

Remote classification society surveys directed by shore personnel and using crew handling cameras became increasingly common as Covid-19 lockdowns prevented surveyors travelling to some locations. Covid aside, a remote survey avoids waiting time for a surveyor to reach the vessel, as well as unnecessary travel costs.

Most class societies carried out remote surveys and are now considering the roll out of remote surveys under more normal conditions not least because travel costs and delays are eliminated, the surveys are quicker, produce survey documentation instantly and thus allow updates of survey status on electronic records.

Over the horizon

Remote monitoring and assistance of equipment was making slow inroads into marine circles in the years before the COVID pandemic but looks to be something that more operators will be willing to participate in. The ability to use 4G cell phone technology in ports has assisted but the availability of more satellite bandwidth can bring the same remote capabilities to vessels at sea well out of range of shore communication networks.

AR in particular has the potential to transform maintenance and emergency assistance as ship side user only needs to be a physical presence while the experience and knowledge is provided by the shore side experts.

08

Cyber Security

Cyber security has become a necessary fact of life in the computer age especially since connectivity to the internet has become the norm. There are still stand alone computer systems to be found on ships, but these are becoming increasingly scarce and even some systems that were not planned to be linked to the outside world are vulnerable if they are upgraded or designed by way of USB sticks or the like.

Even when computers were installed on ships as a replacement for typewriters so that crew lists and other documents could be produced and printed for customs purposes, it was not unusual for someone to attempt to install pirated software on them causing malfunctions.

Today shipping is ever more reliant on digital solutions for a wide range of routine tasks from receiving messages, updating ECDIS and other systems, stability calculations, equipment monitoring, training and administration. All designed to save time and costs and improve efficiency, these developments to a large extent rely on increased connectivity often via internet between servers, IT systems and OT systems, which renders them vulnerable to cyberattacks.

The potential for navigation and safety to be jeopardised by attacks whether malicious, criminal in intent or an inadvertent interference with a vital system prompted the IMO in 2017 to recommend ship operators to address the issue in their safety management systems.

That recommendation came into effect at the start of 2021. The IMO resolution MSC.428(98) and the high level guidelines devised to aid operators, although often quoted as being requirements, will only have legal status if adopted by flag states as a mandatory requirement.

Nevertheless, pro-active operators had already put preventative measures in place and only a few blasé operators will ignore the recommendation entirely or pay lip service to it with a meaningless insertion into their SMS around 'mitigating cyber threat to an acceptable level, considering costs and benefits of actions taken'.

Those following the IMO guidelines will 'ensure 'effective cyber risk management should start at the senior management level. Senior management should embed a culture of cyber risk management into all levels and departments of an organisation and ensure a holistic and flexible cyber risk governance regime, which is in continuous operation and constantly evaluated through effective feedback mechanisms.' The IMO guidelines take a high level approach, but more practical measures have been disseminated by the likes of BIMCO in association with several shipping organisations, classification societies, P&I clubs, consultants, communications service providers and more.

The BIMCO publication 'The Guidelines on Cyber Security Onboard Ships' provides a very good basis for any ship operator addressing the issue and is far more comprehensive than this guide is intended to be. It can be downloaded free of charge from the BIMCO website. The guide is mostly aimed at threats onboard ships because although an attack can also occur in shore offices, the loss of navigation or propulsion systems on ships is a far greater safety threat.

The BIMCO guide suggests cyber incidents can arise as the result of:

- a cyber security incident, which affects the availability and integrity of OT, for example corruption of chart data held in an Electronic Chart Display and Information System (ECDIS)
- an unintended system failure occurring during software maintenance and patching, for example through the use of an infected USB drive to complete the maintenance
- loss of or manipulation of external sensor data, critical for the operation of a ship. This includes but is not limited to Global Navigation Satellite Systems (GNSS), of which the Global Positioning System (GPS) is the most frequently used.
- failure of a system due to software crashes and/or "bugs"
- crew interaction with phishing attempts, which is the most common attack vector by threat actors, which could lead to the loss of sensitive data and the introduction of malware to shipboard systems.

Later the guide says it is important to protect critical systems and data with multiple layers of protection measures, which consider the role of personnel, procedures and technology to both increase the probability that a cyber incident is detected and to make the best use of resources required to protect confidentiality, integrity, and availability of data in IT and OT systems.

Connected OT systems on board should require more than one technical and/or procedural protection measure. Perimeter defences such as firewalls are important for preventing unwelcomed entry into the systems, but this may not be sufficient to cope with insider threats.

Company SMS policies and procedures should help ensure that cyber security is considered within the overall approach to safety and security risk management. The complexity and potential persistence of cyber threats means that a "defence in depth" approach should be considered. Equipment and data protected by layers of protection measures are more resilient to cyber incidents.

Effective segregation of systems, based on necessary access and trust levels, is one of the most successful strategies for the prevention of cyber incidents. Effectively segregated networks can significantly impede an attacker's access to a ship's systems and is one of the most effective techniques for preventing the spread of malware.

Onboard networks should be partitioned by firewalls to create safe zones. Firewall configurations should be reviewed regularly to detect unauthorised changes. The fewer communications links and devices in a zone, the more secure the systems and data are in that zone. Confidential and safety critical systems should be in the most protected zone.

Wireless access to networks on the ship should be limited to appropriate authorised devices and secured using a strong encryption key, which is changed regularly. Awareness and training with regard to cyber security is essential to address the human element. In developing a training programme or devising new safety procedures,

BIMCO suggests that the following should be taken into account.

- risks related to emails and how to behave in a safe manner. Examples are phishing attacks where the user clicks on a link to a malicious site or opens a malicious attachment
- risks related to internet usage, including social media, chat forums and cloud-based file storage where data movement is less controlled and monitored
- risks related to geolocation data for personnel and ship that is publicly available
- risks related to the use of own devices. These devices may be missing security patches and controls, such as anti-virus, and may transfer the risk to the environment, to which they are connected
- risks related to installing and maintaining software on company hardware using infected hardware (removable media) or software (infected package)
- risks related to poor software and data security practices, where no anti-virus checks, or authenticity verifications are performed
- safeguarding user information, passwords and digital certificates
- cyber risks in relation to the physical presence of non-company personnel, eg, where third party technicians are left to work on equipment without supervision
- detecting suspicious activity or devices and how to report a possible cyber incident. Examples of this are strange connections that are not normally seen or someone plugging in an unknown device on the ship network
- awareness of the consequences or impact of cyber incidents to the safety and operations of the ship
- understanding how to implement preventative maintenance routines such as anti-virus and antimalware, patching, backups, and incident-response planning and testing
- procedures for protection against risks from service providers' removable media before connecting to the ship's systems.

In addition, personnel need to be made aware that the presence of anti-malware software does not remove the requirement for robust security procedures, for example controlling the use of all removable media.

Cyber security of the radio and satellite connection should be considered in collaboration with the service provider. In this connection, the specification of the satellite link should be considered when establishing the requirements for onboard network protection.

Protection against eavesdropping is typically done by means of Virtual Private Network (VPN) connection or encrypted protocols. While protection against hacking, piercing and other types of attack can be achieved by other means such as a security arrangement with the service provider, connection through a secure server ashore for example owned by the company, or an onboard firewall.

One important aspect of cyber security is to make the satellite terminal invisible. This can be achieved by deactivating functions such as "remote administration page" and "port forward". Deactivation can typically be done in the terminal's settings menu.

When establishing a connection for a ship's navigation and control systems to shore-based service providers, consideration should be given on how to prevent illegitimate connections gaining access to the onboard systems.

The access interconnect is the distribution partner's responsibility. The final routing of user traffic from the internet access point to its ultimate destination onboard ("last mile") is the responsibility of the shipowner. User traffic is routed through the communication equipment for onward transmission onboard. At the access point for this traffic, it is necessary to provide data security, firewalling and a dedicated "last-mile" connection.

When using a VPN, the data traffic should be encrypted to an acceptable international standard. Furthermore, a firewall in front of the servers and computers connected to the networks (ashore or on board) should be deployed. The distribution partner should advise on the routing and type of connection most suited for specific traffic. Onshore filtering (inspection/blocking) of traffic is also a matter between a shipowner and the distribution partner. Both onshore filtering of traffic and firewalls/security inspection/blocking gateways on the ship are needed and supplement each other to achieve a sufficient level of protection.

Although a VPN is intended to increase security, in some cases multiple VPNs are being operated by different suppliers and manufacturers to connect with equipment, this may take control of access away from the Ship Manager. and increase the Attack Surface of the ship.

Manufacturers of satellite communication terminals and other communication equipment may provide management interfaces with security control software that are accessible over the network. This is primarily provided in the form of web-based user interfaces. Protection of such interfaces should be considered when assessing the security of a ship's installation. Examples of protection of administrative interfaces include limiting networks that can access such interfaces whether they are web-based or command line or entirely disabling unnecessary interfaces that are only used during initial configuration. As for other systems, the passwords should be managed appropriately and default passwords, which are often well-known to criminals, should be changed from the outset.

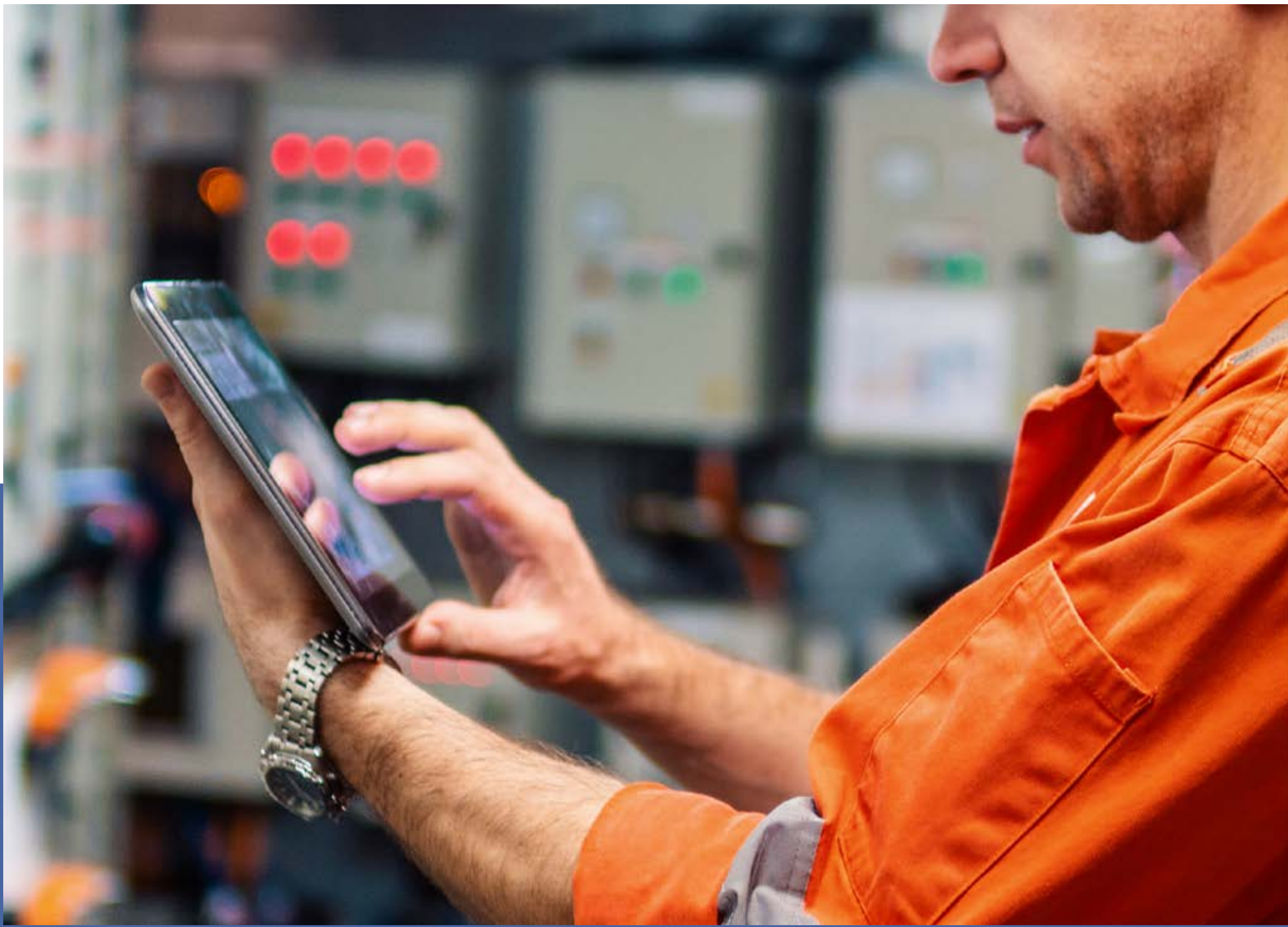
Cyber attackers do not stand still and are constantly finding new ways to exploit weaknesses in systems and networks. Consequently, managing the cyber security system is essential.

Security patches should be included in the periodic maintenance cycle and it is recommended to pay special attention to equipment utilized to do virtual network segregation (VLAN) and firewalling. These updates or patches should be applied correctly and in a timely manner to ensure that any vulnerabilities in a system are addressed before they are exploited and available to hackers. It can be complicated and expensive to patch some OT systems, because all software and hardware firmware needs to be aligned and thorough tests must be conducted post installation to validate the integrity. In other cases, security patches may not be applicable without upgrading system hardware partly or completely.

Over the horizon

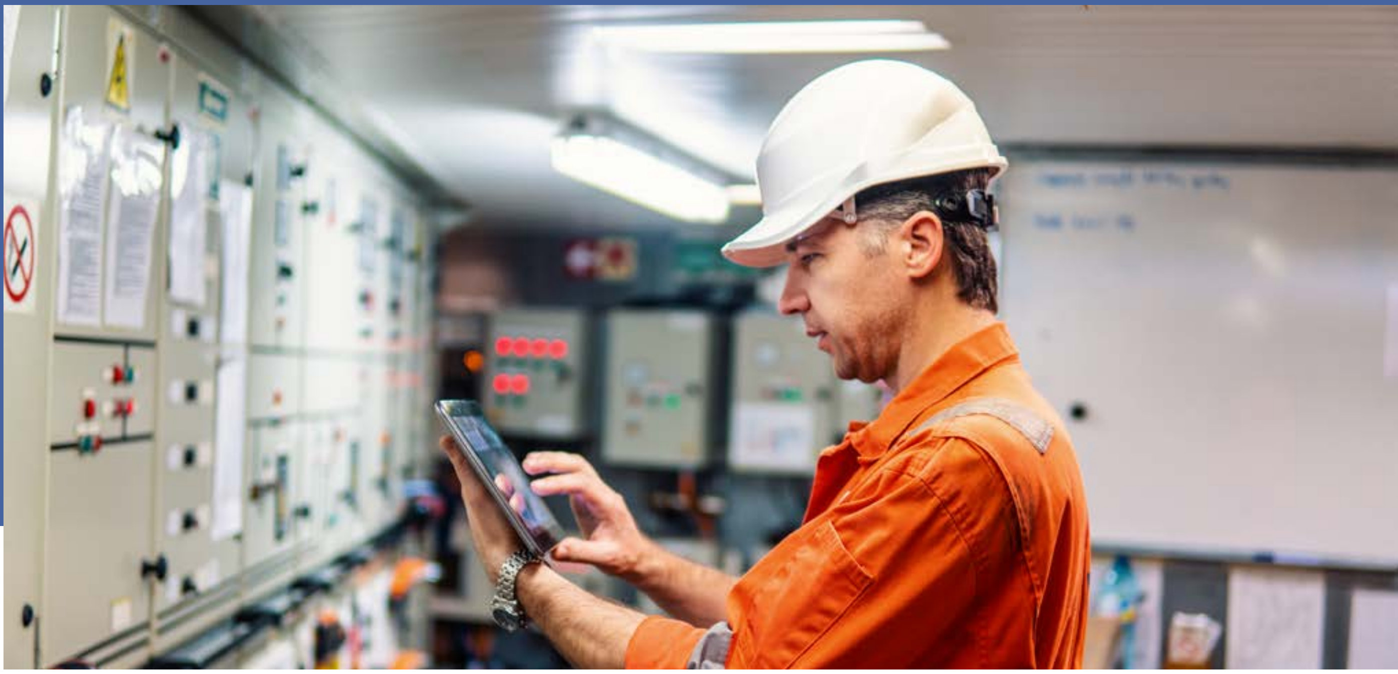
The battle against cyber criminals is a never ending one. What works today as protection may not work tomorrow. It is essential to keep abreast of developments and take action as appropriate. For ships it is especially important to ensure that communication service providers are offering up to date protection through their various products.

With a new version of Windows (Windows 11) now in circulation, Microsoft will be withdrawing support for Windows 10 in 2025. Older operating systems will then become vulnerable.



Section 03

Special services



09

Training

Training for seafarers, whether officers or ratings, has historically been a combination of theoretical and practical basic training undertaken in shore training establishments and sea time on vessels at sea. The skills level for different ranks is laid down in the STCW Convention and all appropriate training and examination will need to be satisfactorily completed for career progression.

As well as the basic training that all seafarers undergo, ship operators will want to ensure that officers and crew are able to operate the equipment and systems on the ship in which they are serving. When the ship is new, it is normal for the supplier to offer some training to one or two personnel selected by the owner at a training facility. When equipment is retrofitted, some equipment makers will do the same but sometimes it is necessary for the shipowner to arrange training.

In addition to item specific training, seafarers need to take part in regular drills for things such as lifeboat launching or fire fighting. A well operated ship will also want their crews to take part in safety meetings and reinforce training using resources such as films and videos. Activities such as these are now written into the safety management systems of ship operators – or at least they should be.

Onboard training films using film and projectors have been around since the days of black and white films.

Videotel, one of the most well-known producers of marine training material was founded in 1973 and is a good example of how training is one area where shipping has fully embraced digitalisation.

The company has always made its own training films which cover the whole gamut of work and equipment on board all ship types and has at times added an entertainment element to them using techniques such as gamifying some of their titles.

In common with similar organisations, Videotel's early method of operation was to supply a selection of films to ships and to change them at regular intervals to a new selection chosen by the ship or in accordance with a schedule established with the shipowner. The films – later on videotape and then on DVDs – were hired from Videotel and not owned by the ship.

In the mid-2000s, Videotel moved some of its title to an online service and launched an on demand service. It also moved into the computer-based training (CBT) sector with system specific ECDIS instructional training programmes. In 2014, it was acquired by KVH being seen as ideally suited to that company's VSAT and entertainment offerings.

CBT took off in the maritime sphere with several other service providers providing a wide range of subjects. In 2010 the Norwegian e-learning company Seagull launched an online version of its Seagull Training Administrator (STA) crew training software, offering offer access to Seagull's full computer-based onboard training library via the internet. The system gave shore staff the opportunity to check on STA training records and statistical reports, as well as opening up access to all 149 of Seagull's Computer Based Training (CBT) programmes from anywhere in the world via an internet connection and a compatible browser.

By 2018 Videotel had added VR to its training services following a co-operation with OMS-VR. A year earlier it had adapted its training material for use on mobile phones and tablets extending the learning possibilities for users. The system incorporates HTML5 responsive-design capabilities, where content can rescale dynamically to any screen size or aspect ratio. Additional features include touch navigation, a multi-language capability allowing users to switch between languages, and an ECDIS-inspired 'night mode' that allows the user to select a darker theme.

In 2020 Videotel and Seagull were combined into the Ocean Technology Group after the former was sold by KVH. Having brought the two trainers together OTG established its Ocean Learning Platform an enterprise level maritime learning management system designed to unite shore based and onboard training initiatives, online and across mobile devices. It delivers blended learning, assessment and competency management solutions that completely connect e-Learning and hands-on activity to improve knowledge, skills and behavioural development.

At its core is a new Ocean Learning Library bringing together materials from across the brands. Upgraded software-enabled features and the introduction of micro-learning and gamified content is aimed at further enhancing crew engagement encouraging the adoption of personalised and immersive learning sessions. Users can now combine information and content specific training for their companies and fleets, to complement the Ocean Learning Library. This is now further-enabled through an integrated rapid authoring tool, which allows companies to quickly create customised and trackable e-Learning content on subject areas of critical importance to the company.

Similarly, a pulse survey tool is now available that allows ship managers and crew managers to actively engage with their seafarers on a range of interactive applications such as employee experience, safety and operational matters and in-house campaigns.

Survey data is then returned from the vessel and online sources providing insight and facilitating data-driven decision making.

Simulator training is an established instruction method in many industries and shipping is no exception. In response to a shortage of officers over the last two decades, greater use is being made of simulator training to allow more officers to qualify. High end simulators are produced by a number of specialists with Wärtsilä Voyage (previously Transas) and Kongsberg being the sector's major players but there are several others some of whom specialise in a particular vessel type or particular types of equipment such as engines, cranes and even lifeboat handling systems.

Simulators can vary from a simple desktop or laptop computer to full mission bridge simulators that recreate a ship's navigation bridge – in some cases identical to a specific ship for training crews before being posted to the actual ship. In shore-based training establishments, there is clearly no need for a communication element beyond the occasional use of multiple connected simulators in an exercise scenario that may also include a physical vessel at sea.

In a recent trend, simulator training is moving to take place at sea while crew are serving on the ship. At a basic level this corresponds to the CBT situation with a single screen and a keyboard being the input devices. Quite clearly it would be impractical to install a full mission simulator on a ship and the ship's own equipment is not intended for dual use although a ship with a dual ECDIS system could perhaps use one for training while the other is in use.

In the summer of 2021, SQLearn a Greece-based e-learning provider announced its Brave Dolphin project, aiming to create the ultimate VR training tool for maritime. Aiming to expand its training services, SQLearn is developing a Virtual Reality Application as a training tool for crew members, regarding emergencies that may occur on board.

Maritime safety risk cases are difficult to be simulated in a real environment but the Brave Dolphin VR training solution will mainly include simulations of real-case scenarios of crucial incidents. The scenarios selected to be simulated in a VR environment were identified by expert maritime consultants, who have conducted a Risk Analysis on crucial incidents that occur on board.

The Brave Dolphin project will include four VR training scenarios giving the chance to crew members to learn "How to test the Emergency Generator", handle a "Fire in the Engine Control Room" and "Enclosed space fire" as well get familiarised with the "Lifeboat Drill Procedure".

Upon the project's completion, Brave Dolphin will be further enriched with more scenarios and will be added to the Company's umbrella of services branded as "Dolphin Platforms", designed & developed by SQLearn, especially for maritime companies. These services are certified by the American Bureau of Shipping (ABS) according to ABS Standards for Certification of Maritime Education Facilities & Training Courses.

Over the horizon

There are significant benefits from onboard training and e-learning where practical hands-on knowledge will be complemented by individual CBT and VR training leading to STCW compliance. This will reduce the need for time spent training on shore and the travel costs involved more than offsetting extra communication costs.

With some equipment suppliers already using VR as a training tool, it is inevitable that simulator manufacturers and training establishments will move forward with VR and AR for long distance training including onboard ship. It may even be possible using VDR data, for crew to use simulation and VR technology to replay incidents and identify better ways to address issues.

Ship operators will, through oversight of training by senior officers on board and instant access to results of tests/assignments/examinations, be better able to determine an individual's abilities and their promotional prospects. The trainees can instantly relate learning to reality thus reinforcing the learning process.

10

Telemedicine

Injuries and illness on board ships are an unfortunate reality for seafarers and ship operators. Except for some passenger ships which are obliged to carry qualified doctors on board, immediate medical assistance will normally be limited to the first aid abilities of the crew, the contents of the ship's medicine chest and the guidance given by the International Medical Guide For Ships and the associated Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG) or whatever other reference books are carried on board.

The usefulness of that guidance may be diluted by the books being in a language that is not necessarily the mother tongue of the person using it and by it containing specialist medical terms which may make finding the advice difficult.

Fortunately for seafarers, what is now known as telemedicine has a surprisingly long history dating back to the early years of the 20th Century when expert advice could be obtained using the new medium of radiotelegraphy invented by Marconi. The first dedicated services for ships offering free assistance date to the 1920s and 1930s and by 1932 The International Telecommunication Union (ITU) was publishing details of coastal radio stations that could link to the available services.

Although this was a laudable development, and probably well received by seafarers and shipping companies alike, they should not be forgotten that the doctors involved were generally speaking to crew members without a basic knowledge of medicine and therefore the ability to describe the patient's condition and symptoms would have been limited and potentially resulted in many wrong diagnoses being made.

More to the point, even expert medical appraisal is no substitute for treatment in emergency cases that require the use of drugs not carried onboard or surgical operations. Ships are still reliant on medevac services and that may mean a diversion is necessary. Depending upon the ship type, service and distance from land, a diversion can means additional costs of up to $200,000. Such a cost is justifiable under most circumstances but there is anecdotal evidence that many 'emergencies' turn out to be minor illnesses that did not need emergency assistance.

Ships in port can usually avail themselves of local medical services and for most ships, their P&I Club will likely cover the cost of emergency treatment for ships at sea often thousands of miles from land and beyond the reach of medical evacuation, the remote advice services are still available and the extent of service they can offer has increased significantly already for ships with appropriate equipment on board.

At a very early stage in the marine satellite era in 2001, a Norwegian company called iMed piloted a service with a local shipowner in which a digital camera was used to transmit images and a modified ECG machine could send readings ashore. In 2009, TeleMedic Systems tested its Vitalink monitoring system over the Iridium network which at that time was limited in bandwidth. The VitalLink3 is a small, lightweight and durable telemedicine device that connects to and communicates with medical sensors. It can transmit details of pulse, blood pressure, temperature, blood oxygen content and more allowing the doctor at the shore end to make much more accurate diagnoses.

The VitalLink3 unit collects the date provided by the peripherals, organises it into a consistent, synchronized format and then sends the information over a data link to the VitalNet server. Standard Windows PC's, laptops or tablets can connect to the VitalNet for viewing the data either live as it is received or any time after the event.

Today there are several services that offer a modern telemedicine service for ships but penetration into the commercial ships sector is still a long way behind cruise ship provision. The service providers or maybe enablers come from different backgrounds with some being charitable or subscription medical professionals, others equipment suppliers and in the case or Marlink's Telemed a communication service provider. All operate along the same lines as the iMed and Telemedic services mentioned above but with more sophisticated medical equipment made available on board.

There are few published statistics on the number of incidents where remote medical assistance has been provided using modern communication facilities it is difficult how easy they are to use and how reliable. A 2012 study (Dehours E, Vallé B, Bounes V et al. User satisfaction with maritime telemedicine. J Telemed Telecare 2012)reported that, while ECG equipment was available in quite a lot of ships, actual recording was problematic in 23% of the cases, and transmission of the results was an issue in 17% of the cases.

In the intervening years, bandwidth available for marine communications has increased considerably with the uptake of VSAT

While emergency assistance is a vital aspect of telemedicine, there are more routine matters that are also being offered by a number of companies. Ships are obliged to have on board a variety of medicines, dressings, appliances and equipment by IMO and flag state regulations.

Normally a room on a ship is designated as the medical room and the drugs and equipment needs to be properly stored and managed there as well as emergency first aid stations around the ship.

Ensuring the ship's medicine chest contents are appropriate and in date is an aspect that can sometimes be overlooked or poorly controlled. A service such as the ShipMed Safety System offered by Norwegian company Medi3 is a practical solution. The cloud-based software solution ensures regulatory compliance at all times, and value added services keep the vessel several steps ahead of existing compliance requirements. It includes medical supplies, log and purchasing reports and to-do lists, as well as a separate report on narcotic medicines, to provide a greater level of control and peace of mind to the medical personnel responsible for the medical facility. The system also provides quick references for medical equipment needed for different injuries, and videos demonstrating various medical procedures.

Over the horizon

The COVID pandemic has accelerated the use of remote medical assistance on shore and simultaneously highlighted the problems faced by seafarers who in some cases were refused access to shore facilities even though their ship was anchored offshore or in port. As more experience of the success of examination by video link is gained, it is likely that this can be migrated to marine use.

Coupled with greater experience of diagnosing by video, better communications and bandwidth will enable much improved display of injuries and symptoms. Having equipment such as defibrillators onboard will then put seafarers in perhaps a better place even than people ashore who are unlikely to have that available. The cost of equipment and the better bandwidth would certainly be far less than the cost of just one or two unnecessary diversions in the working life of a ship.

11

Future communications planning

When it comes to the matter of choice of communication systems for ships, operators will have three key requirements: it should be sufficient to address needs, it must be reliable and it should be cost effective.

As things stand, the future communication needs for ships and shipowners are still in the process of being determined and often the driving factors will be outside of the owners' control and dependent on technologies not yet delivered or even conceived. Just three decades ago, few shipowners would have dreamed of the changes that GMDSS – then just starting to be implemented – would bring.

The 1990s may have been the beginning of the internet age but the early hype rarely lived up to expectation and billions of dollars were lost. Even Iridium, now a GMDSS service provider but then just another newcomer in the communications arena was to go bankrupt along with dozens of new technology companies when the dot.com bubble burst.

Today, the benefits of digitalisation are more accepted and the products on offer generally much more directed at genuine demand for them.

Having shelled out on GMDSS systems and later AIS, LRIT and SSAS, shipowners were more aware that regulation was driving digitalisation and they needed to keep up. Not least because future regulation looks set to impact operations far more than the relatively small cost of equipment prices required up to now.

Efficiency, environmental restrictions in certain areas and a potential levy on fuel use are some of the new drivers. Enlightened operators have also taken crew welfare onboard and looked at cost saving measures. As a result, many have adopted services such as performance monitoring and for safety and operational reasons remote maintenance.

As regulators look to control more aspects of ship operation, e-Navigation has become an issue that most feel will soon become mandatory in some form or other. E-Navigation will impose a very high loading on the ship's data transmission and reception requirements as the concept is based on the interconnection of ships and shore facilities by communication links, including high speed broadband data to ensure safe navigation particularly in coastal and high traffic areas.

New technology such as VDES is mooted to be at the heart of e-navigation because it has the potential to provide many forms of data to ships, such as Maritime Safety Information (MSI), hydrographic and environmental data, piracy and security reporting, updating and monitoring of onboard systems both electronic and mechanical. VDES uses the VHF part of the spectrum.

Ship operators are also keeping a weather eye on the autonomous ship issue.

Assuming there is societal acceptance of uncrewed passenger transports, it is fairly certain that short distance autonomous craft will become a feature in some parts of the world within the next decade. The position with regard to cargo ships is somewhat less certain. From an operator's point of view, the ability to dispense with some or all of the crew, will be a cost saving but although human error is said to cause more than half of all maritime incidents, there is no counting of the times when catastrophes have been averted or cargoes saved by the timely action of the crew in dealing with a situation not caused by human neglect or intervention.

From a communications point of view, it is hard to determine where the greater communication need might arise. An autonomous ship may need to transmit and receive more data for navigation purposes and equipment monitoring but it will not have any crew related communications. A manned ship will need crew and company related communications but may not have a need to transmit or receive any other data.

In planning future needs, an owner will first need to decide on a GMDSS provider. Flag states may have a role in this decision but if not, the owner will be free to choose from any provider (currently only Inmarsat and Iridium) approved by the IMO. The choice of GMDSS service provider will also to some extent dictate the choice of the prime communications equipment but it will not restrict the choice of communications service provider(s).

Researching the market of communications service providers is where the most planning and decision making will come in although initially the ship operator needs to consider the degree of digital integration existing in a ship's systems and how it relates to cyber threats.

Operational technology (OT) is the management and control of ship systems by combinations of hardware and software. The effectiveness of any piece of equipment relies on it being able to activate immediately required and in a consistent known manner.

Many shipbuilders are now constructing SMART ships where far more of the controls are automated and networked.

IT on the other hand are technologies for information processing, including software, hardware and communication technologies. It may be found in monitoring systems where sensors acquire data which is recorded and may be used to analyse performance or indicate appropriate measures for crew to take to optimise performance.

Although they may be called in to install or assist in troubleshooting, IT departments are not usually involved in the purchase of OT systems which is the remit of the superintendents or vessel engineers who may not have sufficient knowledge to evaluate cyber risks. It is, therefore, important to have a dialogue with the IT department to ensure that cyber risks are considered during the OT purchasing process.

In a small sized ship owning or operating organisation, the IT department might also be ignorant of all aspects of cyber risk and the choice then is to employ a specialist consultant or ask class, P&I and communication service providers for some assistance in gauging and preventing cyber threats. Consideration could be giving to segregating systems on board so as to minimise or eliminate some of the risk that arise from poorly protected IT systems.

Planning a communications strategy is not only about controlling cyber risks but also anticipating future needs and solutions. Ship operators are no better at predicting how communications technology will develop than any other individual but that does not prevent them from discussing the question with a communications service provider. Although they will have their own products and favoured networks, a decent provider will be conversant with the possibilities offered by new satellite networks that are being constructed and by new technologies such as 5G for example. Most will have suitable systems and services that can be tailor made or adapted to suit the specific needs of any shipowner.

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