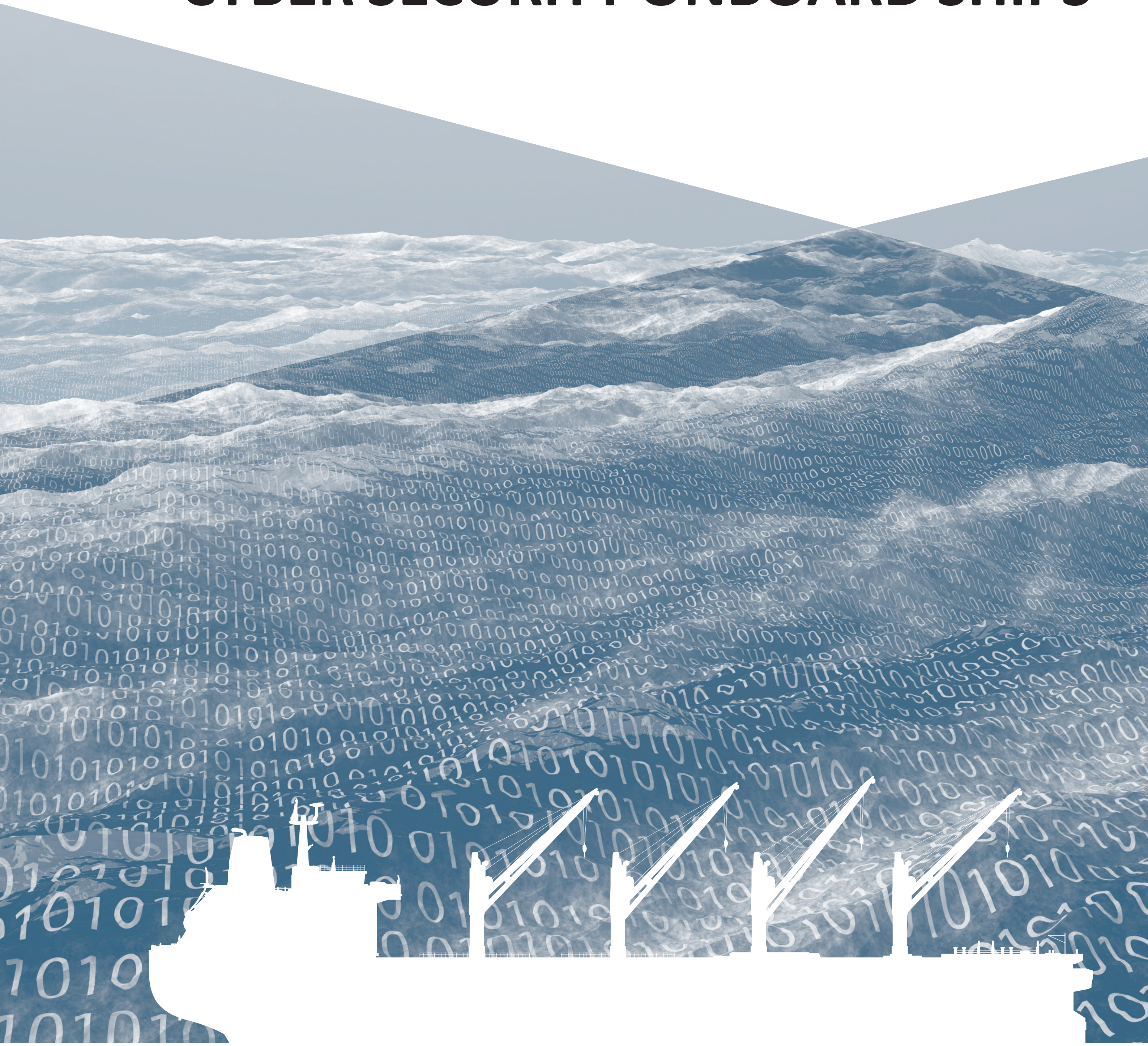
THE GUIDELINES ON
CYBER SECURITY ONBOARD SHIPS



Produced and supported by
BIMCO, CLIA, ICS, INTERCARGO, INTERTANKO, OCIMF and IUMI

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Version 2.0

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Introduction

Ships are increasingly using systems that rely on digitisation, integration, and automation, which calls for cyber risk management on board. As technology continues to develop, information technology (IT) and operational technology (OT) onboard ships are being networked together – and more frequently connected to the internet.

This brings the greater risk of unauthorised access or malicious attacks to ships' systems and networks. Risks may also occur from personnel accessing systems on board, for example by introducing malware via removable media.

The safety, environmental and commercial consequences of not being prepared for a cyber incident may be significant. Responding to the increased cyber threat, a group of international shipping organisations, with support from a wide range of stakeholders (please refer to annex 4 for more details), have developed these guidelines, which are designed to assist companies develop resilient approaches to cyber security onboard ships.

Approaches to cyber security will be company- and ship-specific, but should be guided by appropriate standards and the requirements of relevant national regulations. The guidelines provide a risk-based approach to identifying and responding to cyber threats. An important aspect is that relevant personnel should have training in identifying the typical modus operandi of cyber attacks.

The International Maritime Organization (IMO) has developed guidelines[1] that provide high-level recommendations on maritime cyber risk management to safeguard shipping from current and emerging cyber threats and vulnerabilities. The Guidelines on Cyber Security Onboard Ships are aligned with the IMO guidelines and provide practical recommendations on maritime cyber risk management covering both cyber security and cyber safety.

The aim of this document is to offer guidance to shipowners and operators on how to assess their operations and put in place the necessary procedures and actions to maintain the security of cyber systems onboard their ships. The guidelines are <u>not</u> intended to provide a basis for and should not be interpreted as calling for auditing or vetting the individual approach to cyber security taken by companies and ships.

NIST framework

The National Institute of Standards and Technology, US Department of Commerce (NIST) framework has been used during the development of these guidelines. NIST aims to help understand, manage and express cyber security risks both internally and externally, for example within a ship's organisation. It can help to identify and prioritise actions for reducing cyber security risks. It is also a tool for aligning policy, business and technological approaches to manage the risks.

[1] MSC-FAL.1/Circ.3 on Guidelines on maritime cyber risk management

1. Cyber security and safety management

Cyber safety is as significant as cyber security. Both have equal potential to affect the safety of onboard personnel, ships, and cargo. Cyber security is concerned with the protection of IT, OT and data from unauthorised access, manipulation and disruption. Cyber safety covers the risks from the loss of availability or integrity of safety critical data and OT.

Cyber safety 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)
- A failure occurring during software maintenance and patching
- 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).

Whilst the causes of a cyber safety incident may be different from a cyber security incident, an effective response to both is based upon training and awareness of appropriate company policies and procedures. So, this document aims to provide essential guidance on managing cyber safety and cyber security risks.

1.1 Plans and procedures

Company plans and procedures for cyber risk management should be complementary to the existing security and safety risk management requirements contained in the ISM Code[2] and ISPS Code[3]. Cyber security should be considered at all levels of the company, from senior management ashore to onboard personnel, as an inherent part of the safety and security culture necessary for the safe and efficient operation of the ship.

In accordance with chapter 8 of the ISPS Code, the ship is obliged to conduct a security assessment, which should include all operations that are important to protect. The assessment should address radio and telecommunication systems, including computer systems and networks (part B, paragraph 8.3 of the ISPS Code). This calls for controlling and monitoring “the ship to shore” path of the internet connection, which is important owing to the fast adoption of sophisticated and digitalised onboard OT systems that in many cases have not been designed to be cyber resilient.

The objective of the company’s Safety Management System (SMS) is to provide a safe working environment by establishing appropriate safe practices and procedures based on an assessment of all identified risks to the ship, onboard personnel and the environment. In the context of ship operations, cyber incidents are anticipated to result in physical effects and potential safety and/or

[2] International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)

[3] International Ship and Port Facility Security Code (ISPS Code)

pollution incidents. This means that the company needs to assess risks arising from the use of IT and OT onboard ships and establish appropriate safeguards against cyber incidents.

The SMS should include instructions and procedures to ensure the safe operation of ships and protection of the environment in compliance with relevant international and flag state legislation. These instructions and procedures should consider risks arising from the use of IT and OT on board, as appropriate, taking into account applicable codes, guidelines and recommended standards.

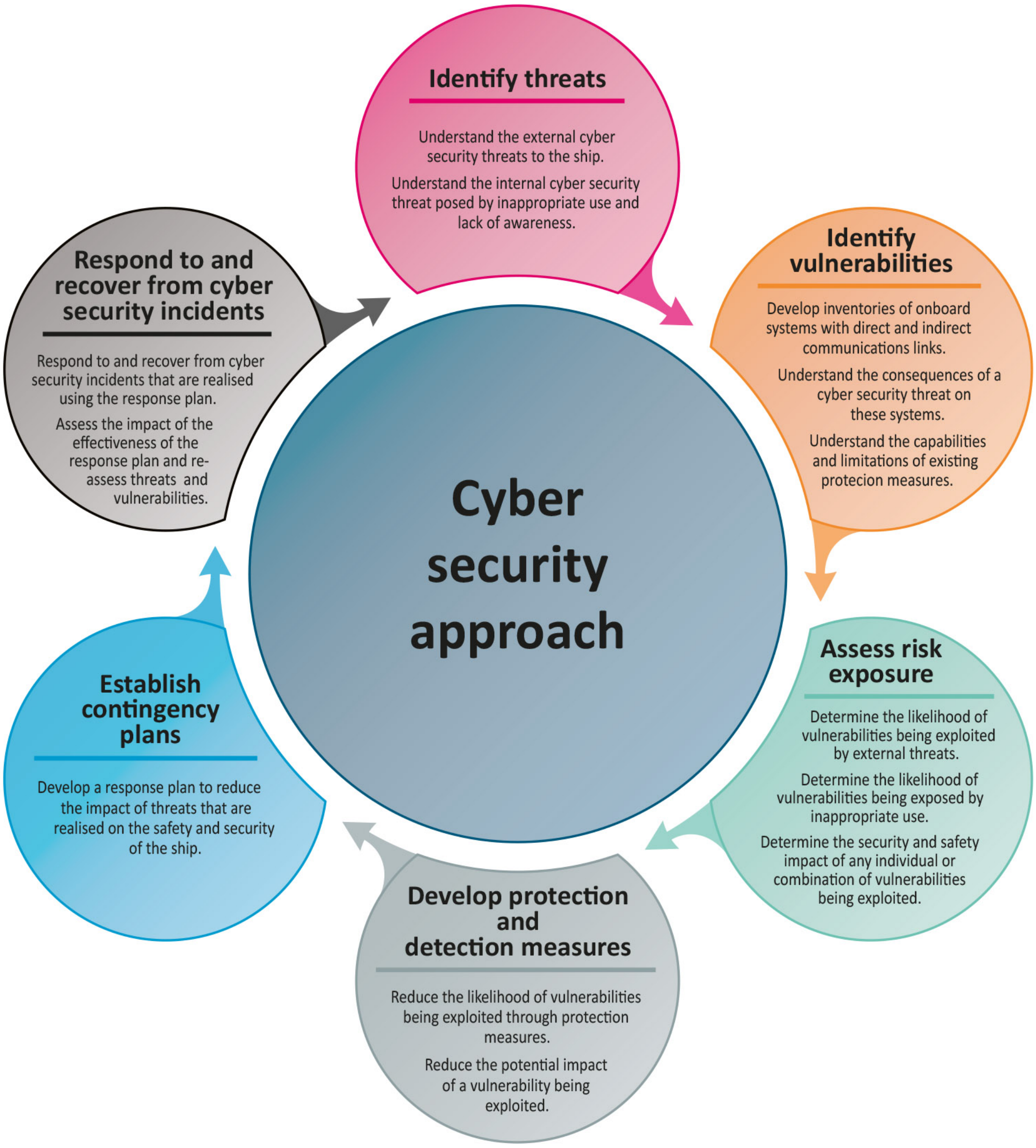
When incorporating cyber risk management into the company SMS, consideration should be given to whether, in addition to a generic risk assessment of the ships it operates, a particular ship needs a specific risk assessment. The company should consider the need for a specific risk assessment based on whether a particular ship is unique within their fleet. This should consider factors, including but not limited to the extent to which IT and OT is used on board, the complexity of system integration and the nature of operations.

Cyber risk management should:

- identify the roles and responsibilities of users, key personnel, and management both ashore and on board
- identify the systems, assets, data and capabilities, which if disrupted, could pose risks to the ship’s operations and safety
- implement technical measures to protect against a cyber incident and ensure continuity of operations. This may include configuration of networks, access control to networks and systems, communication and boundary defence and the use of protection and detection software
- implement activities and plans (procedural protection measures) to provide resilience against cyber incidents. This may include training and awareness, software maintenance, remote and local access, access privileges, use of removable media and equipment disposal
- implement activities to prepare for and respond to cyber incidents.

In recognising that some aspects of work to include cyber risk management in safety management systems may include commercially sensitive or confidential information, companies should consider protecting this information appropriately. As far as possible, policies and procedures included in a safety management system should not include sensitive information like this.

The development, understanding and awareness of key aspects of cyber security and safety as found in these guidelines are highlighted in figure 1 (next page).



Cyber security approach

Identify threats

Understand the external cyber security threats to the ship.

Understand the internal cyber security threat posed by inappropriate use and lack of awareness.

Identify vulnerabilities

Develop inventories of onboard systems with direct and indirect communications links.

Understand the consequences of a cyber security threat on these systems.

Understand the capabilities and limitations of existing protecion measures.

Assess risk exposure

Determine the likelihood of vulnerabilities being exploited by external threats.

Determine the likelihood of vulnerabilities being exposed by inappropriate use.

Determine the security and safety impact of any individual or combination of vulnerabilities being exploited.

Develop protection and detection measures

Reduce the likelihood of vulnerabilities being exploited through protection measures.

Reduce the potential impact of a vulnerability being exploited.

Establish contingency plans

Develop a response plan to reduce the impact of threats that are realised on the safety and security of the ship.

Respond to and recover from cyber security incidents

Respond to and recover from cyber security incidents that are realised using the response plan.

Assess the impact of the effectiveness of the response plan and re-assess threats and vulnerabilities.

Figure 1. Cyber security approach as set out in the guidelines

1.2 Defence in depth and in breadth

Using more than one technical or procedural protection measure is recommended. It is essential to protect critical systems and data with multiple layers of protection measures which take into account the role of personnel, procedures and technology to:

- increase the probability that a cyber incident is detected
- increase the effort and resources required to protect information, data or the availability of IT and OT systems.

This defence in depth approach encourages a combination of:

- physical security of the ship in accordance with the ship security plan (SSP)
- protection of networks, including effective segmentation
- intrusion detection
- software whitelisting
- access and user controls
- appropriate procedures regarding the use of removable media and password policies
- personnel's awareness of the risk and familiarity with appropriate procedures.

Company policies and procedures should 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 attacks.

However, onboard ships where levels of integration between cyber systems may be high, defence in depth only works if technical and procedural protection measures are applied in layers across all vulnerable and integrated systems. This is "defence in breadth" and it is used to prevent any vulnerabilities in one system being used to circumvent protection measures of another system.

Defence in depth and defence in breadth are complementary approaches which, when implemented together, provide the foundation of a holistic response to the management of cyber risks.

2. Identify threats

The cyber risk[4] is specific to the company, ship, operation and/or trade. When assessing the risk, companies should be aware of any specific aspects of their operations that might increase their vulnerability to cyber incidents.

Unlike other areas of safety and security where historic evidence is available and reporting of incidents is required, cyber security is made more challenging by the absence of any definitive information about the incidents and their impact. Until this evidence is obtained, the scale and frequency of attacks will continue to be unknown.

Experiences from other business sectors such as financial institutions, public administration and air transport have shown that successful cyber attacks might result in a significant loss of services, assets and even endanger human lives. Such events argue that the shipping industry should also work proactively to understand and mitigate cyber threats.

There are motives for organisations and individuals to exploit cyber vulnerabilities. The following examples give some indication of the threat posed and the potential consequences for companies and the ships they operate:

Group	Motivation	Objective
Activists (including disgruntled employees)	• Reputational damage • Disruption of operations	• Destruction of data • Publication of sensitive data • Media attention • Denial of access to the service or system targeted
Criminals	• Financial gain • Commercial espionage • Industrial espionage	• Selling stolen data • Ransoming stolen data • Ransoming system operability • Arranging fraudulent transportation of cargo • Gathering intelligence for more sophisticated crime, exact cargo location, off vessel transportation and handling plans etc
Opportunists	• The challenge	• Getting through cyber security defences • Financial gain
States State sponsored organisations Terrorists	• Political gain • Espionage	• Gaining knowledge • Disruption to economies and critical national infrastructure

Table 1. Motivation and objectives

[4] The text in this chapter has been summarised from CESG, Common Cyber Attacks: Reducing the Impact

The groups in Table 1 are active and have the skills and resources to threaten the safety and security of ships, and a company's ability to conduct its business.

In addition, there is the possibility that company personnel, on board and ashore, could compromise cyber systems and data. In general, the company should be prepared that this may be unintentional and caused by human error when operating and managing IT and OT systems or failure to respect technical and procedural protection measures. There is, however, the possibility that actions may be malicious and are a deliberate attempt to damage the company and the ship that is by a disgruntled employee.

Types of cyber attack[5]

In general, there are two categories of cyber attacks, which may affect companies and ships:

- untargeted attacks, where a company or a ship's systems and data are one of many potential targets
- targeted attacks, where a company or a ship's systems and data are the intended target.

Untargeted attacks are likely to use tools and techniques available on the internet which can be used to locate, discover and exploit widespread vulnerabilities which may also exist in a company and onboard a ship. Examples of some tools and techniques that may be used in these circumstances include:

- **Malware:** Malicious software which is designed to access or damage a computer without the knowledge of the owner. There are various types of malware including trojans, ransomware, spyware, viruses, and worms. Ransomware encrypts data on systems until a ransom has been paid. Malware may also exploit known deficiencies and problems in outdated/unpatched business software. The term exploit usually refers to the use of a software or code, which is designed to take advantage and manipulate a problem in another computer software or hardware. This problem can, for example, be a code bug, system vulnerability, improper design, hardware malfunction, and error in protocol implementation These vulnerabilities may be exploited remotely or triggered locally. Locally, a piece of malicious code may often be executed by the user, sometimes via links distributed in email attachments or through malicious websites.
- **Social engineering:** A non-technical technique used by potential cyber attackers to manipulate insider individuals into breaking security procedures, normally, but not exclusively, through interaction via social media.
- **Phishing:** Sending emails to a large number of potential targets asking for particular pieces of sensitive or confidential information. Such an email may also request that a person visits a fake website using a hyperlink included in the email.

[5] In 2016, IHS Markit together with BIMCO carried out a cyber security survey. The respondent from the shipping industry had experienced the mentioned forms of attacks. Four percent of the attacks were directed at ship borne systems.

- **Water holing:** Establishing a fake website or compromising a genuine website to exploit visitors.
- **Scanning:** Attacking large portions of the internet at random.

Targeted attacks may be more sophisticated and use tools and techniques specifically created for targeting a company or ship. Examples of tools and techniques which may be used in these circumstances include:

- **Brute force:** An attack trying many passwords with the hope of eventually guessing correctly. The attacker systematically checks all possible passwords until the correct one is found.
- **Denial of service (DoS):** prevents legitimate and authorised users from accessing information, usually by flooding a network with data. A distributed denial of service (DDoS) attack takes control of multiple computers and/or servers to implement a DoS attack.
- **Spear-phishing:** Like phishing but the individuals are targeted with personal emails, often containing malicious software or links that automatically download malicious software.
- **Subverting the supply chain:** Attacking a company or ship by compromising equipment, software or supporting services being delivered to the company or ship.

The above examples are not exhaustive. Other methods are evolving for example impersonating a legitimate shore based employee in a shipping company to obtain valuable information, which can be used for a further attack. The potential number and sophistication of tools and techniques used in cyber attacks continue to evolve and are limited only by the ingenuity of those organisations and individuals developing them.

Stages of a cyber attack

Cyber attacks are conducted in stages. The length of time taken to prepare a cyber attack can be determined by the motivations and objectives of the attacker, and the resilience of technical and procedural cyber security controls implemented by the company, including those onboard its ships. The four stages of an attack are:

- **Survey/reconnaissance:** Open/public sources used to gain information about a company, ship or seafarer, which can be used to prepare for a cyber attack. Social media, technical forums and hidden properties in websites, documents and publications may be used to identify technical, procedural and physical vulnerabilities. The use of open/public sources may be complemented by monitoring (analysing – sniffing) the actual data flowing into and from a company or a ship.
- **Delivery:** Attackers may attempt to access company and ship systems and data. This may be done from either within the company or ship or remotely through connectivity with the internet. Examples of methods used to obtain access include:
    - company online services, including cargo or consignment tracking systems

    - sending emails containing malicious files or links to malicious websites to personnel
    - providing infected removable media, for example as part of a software update to an onboard system
    - creating false or misleading websites which encourage the disclosure of user account information by personnel.

- **Breach:** The extent to which an attacker can breach a company or ship system will depend on the significance of the vulnerability found by an attacker and the method chosen to deliver an attack. It should be noted that a breach might not result in any obvious changes to the status of the equipment. Depending on the significance of the breach, an attacker may be able to:
    - make changes that affect the system's operation, for example interrupt or manipulate information used by navigation equipment
    - gain access to commercially sensitive data such as cargo manifests and/or crew and passenger lists
    - achieve full control of a system, for example a machinery management system.

- **Effect:** The motivation and objectives of the attacker will determine what effect they have on the company or ship system and data. An attacker may explore systems, expand access and/or ensure that they are able to return to the system in order to:
    - access commercially sensitive or confidential data about cargo, crew and passengers to which they would otherwise not have access
    - manipulate crew or passenger lists, or cargo manifests. this may be used to allow the fraudulent transport of illegal cargo, or facilitate thefts
    - cause complete denial of service on business systems
    - enable other forms of crime for example piracy, theft and fraud
    - disrupt normal operation of the company and ship systems, for example by deleting critical pre-arrival information or overloading company systems.

It is crucial that users of IT systems onboard ships are aware of the potential cyber security risks, and are trained to identify and mitigate such risks.

3. Identify vulnerabilities

It is recommended that a shipping company initially performs an assessment of the potential threats that may realistically be faced. This should be followed by an assessment of the systems and onboard procedures to map their robustness to handle the current level of threat. These vulnerability assessments should then serve as the foundation for a senior management level discussion/workshop. It may be facilitated by internal experts or supported by external experts with knowledge of the maritime industry and its key processes, resulting in a strategy centred around the key risks. The distinction between IT and OT systems should be considered. IT systems focus on the use of data as information whilst OT systems focus on the use of data to control or monitor physical processes.

Stand-alone systems will be less vulnerable to external cyber attacks compared to those attached to uncontrolled networks or directly to the internet. Network design and network segregation will be explained in more detail in annex 2. Care should be taken to understand how critical shipboard systems might be connected to uncontrolled networks. When doing so, the human element should be taken into consideration, as many incidents are initiated by personnel’s actions. Onboard systems could include:

- **Cargo management systems:** Digital systems used for the management and control of cargo, including hazardous cargo, may interface with a variety of systems ashore. Such systems may include shipment-tracking tools available to shippers via the internet. Interfaces of this kind make cargo management systems and data in cargo manifests vulnerable to cyber attacks.

- **Bridge systems:** The increasing use of digital, network navigation systems, with interfaces to shoreside networks for update and provision of services, make such systems vulnerable to cyber attacks. Bridge systems that are not connected to other networks may be equally vulnerable, as removable media are often used to update such systems from other controlled or uncontrolled networks. A cyber incident can extend to service denial or manipulation, and therefore may affect all systems associated with navigation, including ECDIS, GNSS, AIS, VDR and Radar/ARPA.

- **Propulsion and machinery management and power control systems:** The use of digital systems to monitor and control onboard machinery, propulsion and steering make such systems vulnerable to cyber attacks. The vulnerability of these systems can increase when they are used in conjunction with remote condition-based monitoring and/or are integrated with navigation and communications equipment on ships using integrated bridge systems.

- **Access control systems:** Digital systems used to support access control to ensure physical security and safety of a ship and its cargo, including surveillance, shipboard security alarm, and electronic “personnel-on-board” systems.

- **Passenger servicing and management systems:** Digital systems used for property management, boarding and access control may hold valuable passenger related data.

Intelligent devices (tablets, handheld scanners etc.) are themselves an attack vector as ultimately the collected data is passed on to other systems.

- **Passenger facing public networks:** Fixed or wireless networks connected to the internet, installed on board for the benefit of passengers, for example guest entertainment systems. These systems should be considered uncontrolled and should not be connected to any safety critical system on board.
- **Administrative and crew welfare systems:** Onboard computer networks used for administration of the ship or the welfare of the crew are particularly vulnerable when they provide internet access and email. They can be exploited by cyber attackers to gain access to onboard systems and data. These systems should be considered uncontrolled and should not be connected to any safety critical system on board. Software provided by ship management companies or owners is also included in this category.
- **Communication systems:** Availability of internet connectivity via satellite and/or other wireless communication can increase the vulnerability of ships. The cyber defence mechanisms implemented by the service provider should be carefully considered but should not be solely relied upon to secure every shipboard systems and data.

The above-mentioned onboard systems consist of potentially vulnerable equipment which should be reviewed during the assessment. More detail can be found in annex 1 of these guidelines.

3.1 Ship to shore interface

Ships are becoming more and more integrated with shoreside operations because digital communication is being used to conduct business, manage operations, and stay in touch with head office. Further, critical ship systems essential to the safety of navigation, power and cargo management have been increasingly digitalised and connected to the internet to perform a wide variety of legitimate functions such as:

- engine performance monitoring
- maintenance and spare parts management
- cargo, crane and pump management
- voyage performance monitoring.

The above list provides examples of this interface and is not exhaustive. The above systems provide data which may be of interest to cyber criminals to exploit.

Modern technologies can add vulnerabilities to the ships especially if there are insecure designs of networks and uncontrolled access to the internet. Additionally, shoreside and onboard personnel may be unaware how some equipment producers maintain remote access to shipboard equipment and its network system. The risks of misunderstood, unknown, and uncoordinated remote access to an operating ship should be taken into consideration as an important part of the risk assessment.

It is recommended that companies should fully understand the ship’s OT and IT systems and how these systems connect and integrate with the shore side. This requires an understanding of all computer based onboard systems and how safety, operations, and business can be compromised by a cyber incident.

The following should be considered regarding producers and third parties including contractors and service providers:

1. The producer’s and service provider’s cyber security awareness and procedures: Many of these companies lack cyber awareness training and governance in their own organisations and this may represent more sources of vulnerability, which could result in cyber incidents. The companies should have an updated cyber security company policy, which includes training and governance procedures for accessible IT and OT onboard systems.
2. The maturity of a third-party’s cyber security procedures: The shipowner should query the internal governance for cyber network security, and seek to obtain a cyber security assurance when considering future contracts and services. This is particularly important when covering network security if the ship is to be interfaced with the third-party.

Common vulnerabilities

The following are common cyber vulnerabilities, which may be found onboard existing ships, and on some newbuild ships:

- obsolete and unsupported operating systems
- outdated or missing antivirus software and protection from malware
- inadequate security configurations and best practices, including ineffective network management and the use of default administrator accounts and passwords, and ineffective network management which is not based on the principle of least privilege
- shipboard computer networks, which lack boundary protection measures and segmentation of networks
- safety critical equipment or systems always connected with the shore side
- inadequate access controls for third parties including contractors and service providers.

4. Assess risk exposure

Accountability and ownership for cyber security assessment should start at senior management level of a company, instead of being immediately delegated to the ship security officer or the head of the IT department. There are several reasons for this:

1. Initiatives to heighten cyber security may at the same time affect standard business procedures and operations, rendering them more time consuming or costly. It is therefore a senior management level strategic responsibility to evaluate and decide on risk versus reward trade-offs.
2. A number of initiatives which would heighten cyber security are related to business processes and training, and not to IT systems, and therefore need to be anchored organisationally outside the IT department.
3. Initiatives which heighten cyber security awareness may change how the company interacts with customers, suppliers and authorities, and impose new requirements on the co-operation between the parties. It is a senior management level decision whether and how to drive changes in these relationships.
4. Only when the above three aspects have been decided upon will it be possible to clearly outline what the IT requirements of the cyber security strategy will be, and this is the element which can be placed with the IT department.
5. Based on the strategic decisions in general, and the risk versus reward trade-offs, relevant contingency plans should be established in relation to handling cyber incidents if they should occur.

Senior management should realise their leadership responsibilities by delegating authority and allocating the budget needed to carry out the risk assessment and to develop solutions that are best suit for the company and the operation of their ships.

The level of cyber risk will reflect the circumstances of the company, ship (its operation and trade), the IT and OT systems used, and the information and/or data stored. The maritime industry possesses a range of characteristics which affect its vulnerability to cyber incidents:

- the cyber controls already implemented by the company and onboard its ships
- multiple stakeholders are often involved in the operation and chartering of a ship potentially resulting in lack of accountability for the IT infrastructure
- the ship being online and how it interfaces with other parts of the global supply chain
- ship equipment being remotely monitored eg by the producers
- business-critical, data sensitive and commercially sensitive information shared with shore-based service providers

- the availability and use of computer-controlled critical systems for the ship's safety and for environmental protection.

These elements should be considered, and relevant parts incorporated into the company security policies, safety management systems, and ship security plans. Users of these guidelines should refer to specific national legislation and flag state requirements as well as relevant international and industry standards and best practices when developing and implementing cyber risk management procedures.

IT and OT systems, software and maintenance can be outsourced to third-party service providers and the company itself may not possess a way of verifying the level of security supplied by these providers. Some companies use different providers responsible for software and cyber security checks.

The growing use of big data, smart ships and the 'internet of things'[6] will increase the amount of information available to cyber attackers and the potential attack surface to cyber criminals. This makes the need for robust approaches to cyber security important both now and in the future.

Third-party access

Visits to ships by third parties requiring a connection to one or more computers on board can also result in connecting the ship to shore. It is common for technicians, vendors, port officials, marine terminal representatives, agents, pilots, and other technicians to board the ship and plug in devices, such as laptops and tablets. Some technicians may require the use of removable media to update computers, download data and/or perform other tasks. It has also been known for customs officials and port state control officers to board a ship and request the use of a computer to "print official documents" after first inserting an unknown removable media.

Some IT and OT systems are remotely accessible and may operate with a continuous internet connection for remote monitoring, data collection, maintenance functions, safety and security. These systems can be "third-party systems", whereby the contractor monitors and maintains the systems from a remote access. These systems could include both two-way data flow and upload-only. Systems and work stations with remote control, access or configuration functions could, for example, be:

- bridge and engine room computers and work stations on the ship's administrative network
- cargo such as containers with reefer temperature control systems or specialised cargo that are tracked remotely
- stability decision support systems
- hull stress monitoring systems

[6] Lloyd's Register, Qinetiq and University of Southampton, Global Marine Technology Trends 2030

- navigational systems including Electronic Navigation Chart (ENC) Voyage Data Recorder (VDR), dynamic positioning (DP)
- cargo handling, engine, and cargo management systems
- safety and security networks, such as CCTV (closed circuit television)
- specialised systems such as drilling operations, blow out preventers, subsea installation systems, Emergency Shut Down (ESD) for gas tankers, submarine cable installation and repair.

The extent and nature of connectivity of equipment should be known by the shipowner or operator and documented as part of the risk assessment.

Impact assessment

The confidentiality, integrity and availability (CIA) model[7] provides a framework for assessing the impact of:

- unauthorised access to and disclosure of information or data about the ship, crew, cargo and passengers
- loss of integrity, which would modify or destroy information and data relating to the safe and efficient operation and administration of the ship
- loss of availability due to the destruction of the information and data and/or the disruption to services/ operation of ship systems.

The relative importance of confidentiality, integrity and availability changes depending on the use of the information or data. For example, assessing the vulnerability of IT systems related to commercial operations may focus on confidentiality and integrity rather than availability. Conversely, assessing the vulnerability of OT systems onboard ships, particularly safety critical systems, may focus on availability and/or integrity instead of confidentiality.

[7] Federal Information Processing Standards, Publication 199, Computer Security Division Information Technology Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899-8900

Potential impact	Definition	In practice
Low	The loss of confidentiality, integrity, or availability could be expected to have a **limited** adverse effect on company and ship, organisational assets, or individuals	A **limited** adverse effect means that a security breach might: (i) cause a degradation in ship operation to an extent and duration that the organisation is able to perform its primary functions, but the effectiveness of the functions is noticeably reduced; (ii) result in minor damage to organisational assets; (iii) result in minor financial loss; or (iv) result in minor harm to individuals.
Moderate	The loss of confidentiality, integrity, or availability could be expected to have a **substantial** adverse effect on company and ship, company and ship assets, or individuals	A **substantial** adverse effect means that a security breach might: (i) cause a significant degradation in ship operation to an extent and duration that the organisation is able to perform its primary functions, but the effectiveness of the functions is significantly reduced; (ii) result in significant damage to organisational assets; (iii) result in significant financial loss; or (iv) result in significant harm to individuals that does not involve loss of life or serious life threatening injuries.
High	The loss of confidentiality, integrity, or availability could be expected to have a **severe or catastrophic** adverse effect on company and ship operations, company and ship assets, or individuals.	A **severe or catastrophic** adverse effect means that a security breach might: (i) cause a severe degradation in or loss of ship operation to an extent and duration that the organisation is not able to perform one or more of its primary functions; (ii) result in major damage to organisational assets; (iii) result in major financial loss; or (iv) result in severe or catastrophic harm to individuals involving loss of life or serious life-threatening injuries.

Table 2. Potential impact levels when using the CIA model

Sensitive information may include ship position, status of and readout from OT systems, cargo details, authorisations, certificates, etc. When it comes to OT systems it is important consider what impact the loss or malfunction of the system will have following a cyber incident.

Example

A power management system contains a supervisory control and data acquisition (SCADA) system controlling the distribution of onboard electric power. The system contains real-time sensor data which is used on board for power management. It also generates data about the power consumption, which is used by the shipping company for administrative purposes.

To determine if the information above is critical, the consequences likely to result from a compromise to the confidentiality, integrity or availability should be considered. When doing so the shipping company should determine the criticality of the information stored, processed or transmitted by the SCADA system using the most sensitive information to determine the overall impact of the system.

As this OT system is using several measuring points and is integrated with other systems, the company decide to consider the effect of an operational malfunction or loss of the SCADA system due to a cyber incident. In this case, the company concludes that this will have a severe effect and thereby a high impact to the operation of the ship.

Using the CIA model, the shipping company can also conclude that:

- losing confidentiality of the sensor data acquired by the SCADA system will have a low impact as the sensors are publicly displayed on board. However, from a safety point of view, it is important that the information transmitted by the sensors can be relied upon therefore there is a high potential impact from a loss of integrity. It will also be a safety issue if the information cannot be read, and there is therefore a high potential impact from a loss of availability.
- for the power consumption information being sent to the shipping company for statistical purposes, it is assessed that there is a low potential impact from a loss of confidentiality. The company does not want the data to be public, however the effect would be limited if it were to happen. There will also be a low potential impact from a loss of integrity as the data is only used for in-house considerations. There is therefore also a low potential impact from a loss of availability.

The following table shows the result of the assessment:

SCADA system	Confidentiality	Integrity	Availability	Overall impact
Sensor data	Low	High	High	High
Statistical data	Low	Low	Low	Low

Table 3. result of CIA assessment of SCADA system

Bring your own device (BYOD)

It is recognised that personnel may be allowed to bring their own devices (BYOD) on board to access the ships' system or network. Although this may be both beneficial and economical for ships, because these devices may be unmanaged, it significantly increases the possibility of vulnerabilities being exposed. Policies and procedures should address their control, use, and how to protect vulnerable data, such as through network segregation.

4.1 Risk assessment made by the company

As mentioned above, the risk assessment process starts by assessing the systems on board, in order to map their robustness to handle the current level of cyber threats. Elements of a ship security assessment[8] can be used when performing the risk assessment, which should physically test and assess the IT and OT systems on board including:

1. identification of existing technical and procedural controls to protect the onboard IT and OT systems (more information can be found with the Critical Security Controls[9])
2. identification of IT and OT systems that are vulnerable, the specific vulnerabilities identified, including human factors, and the policies and procedures governing the use of these systems (the identification should include searches for known vulnerabilities relevant to the equipment, the current level of patching and firmware updates)
3. identification and evaluation of key ship board operations that are vulnerable to cyber attacks
4. identification of possible cyber incidents and their impact on key ship board operations, and the likelihood of their occurrence to establish and prioritise protection measures.

Companies may consult with the producers and service providers of onboard equipment and systems to understand the technical and procedural controls that may already be in place to address cyber security. Furthermore, any identified cyber vulnerability in the factory standard configuration of a critical system or component should be disclosed to facilitate better protection of the equipment in the future.

4.2 Third-party risk assessments

Self-assessments can serve as a good start, but may be complemented by third-party risk assessments to drill deeper, and identify the risks and the gaps that may not be found during the self-assessment. Penetration tests of critical IT and OT infrastructure can also be performed to identify whether the actual defence level matches the desired level set forth in the cyber security strategy for the company. Such tests can be performed by external experts simulating attacks using both IT-systems, social engineering and, if desired, even physical penetration of a facility's security perimeter. These tests are referred to as active tests because they involve accessing and inserting software into a system. This may only be appropriate for IT systems. Where risk to OT systems during penetration testing is unacceptable, passive testing approaches should be considered. Passive methods rely on scanning data transmitted by a system to identify vulnerabilities. In general, no attempt is made to actively access or insert software into the system.

[8] The assessment described is based on regulation 8 of the ISPS Code

[9] www.cisecurity.org/critical-controls.cfm

4.3 Risk assessment process

Phase 1: Pre-assessment activities

Prior to starting a cyber security assessment on board[10], the following activities should be performed:

- map the ship's key functions and systems and their potential impact levels, for example using the CIA model, taking into consideration the operation of OT systems
- identify main producers of critical shipboard IT and OT equipment
- review detailed documentation of critical OT and IT systems including their network architecture, interfaces and interconnections
- identify cyber security points-of-contact at each of the producers and establish working relationships with them
- review detailed documentation on the ship's maintenance and support of its IT and OT systems
- establish contractual requirements and obligations that the shipowner/ship operator may have for maintenance and support of shipboard networks and equipment
- support, if necessary, the risk assessment with an external expert to develop detailed plans and include producers and service providers.

Phase 2: Ship assessment

The goal of the assessment of a ship's network and its systems and devices is to identify any vulnerabilities that could compromise or result in either loss of confidentiality, loss of integrity or result in a loss of operation of the equipment, system, network, or even the ship. These vulnerabilities and weaknesses could fall into one of the following categories:

1. technical such as software defects or outdated or unpatched systems
2. design such as access management, unmanaged network interconnections
3. implementation errors for example misconfigured firewalls
4. procedural or other user errors.

The activities performed during an assessment would include reviewing the configuration of all computers, servers, routers, and cyber security technologies including firewalls. It should also include reviews of all available cyber security documentation and procedures for connected IT and OT systems and devices.

[10] Based on a third-party risk assessment method described by NCC Group

Phase 3: Debrief and vulnerability review/reporting

Following the assessment, each identified vulnerability should be evaluated for its potential impact and the probability of its exploitation. Recommended technical and/or procedural corrective actions should be identified for each vulnerability in a final report.

Ideally, the cyber security assessment report should include:

- executive summary – a high-level summary of results, recommendations and the overall security profile of the assessed environment, facility or ship
- technical findings – a detailed, tabular breakdown of discovered vulnerabilities, their probability of exploitation, the resulting impact, and appropriate technical fix and mitigation advice
- prioritised list of actions – the priorities allocated should reflect the effectiveness of the measure, the cost, the applicability, etc. It is important that this list does not represent a list of services and products the third-party risk assessor would like to sell, instead of being a complete list of options available
- supplementary data – a supplement containing the technical details of all key findings and comprehensive analysis of critical flaws. This section should also include sample data recovered during the penetration testing of critical or high-risk vulnerabilities
- appendices – detailed records of all activities conducted by the cyber security assessment team and the tools used during the engagement.

Phase 4: Producer debrief

Once the shipowner has had an opportunity to review, discuss and assess the findings, a subset of the findings may need to be sent to the producers of the affected systems. Any findings, which are approved by the shipowner for disclosure to the producers, could further be analysed with support from external experts, who should work with the producer’s cyber security point of contact to ensure that a full risk and technical understanding of the problem is achieved. This supporting activity is intended to ensure that any remediation plan developed by the producer is comprehensive in nature and the correct solution to eliminate the vulnerabilities identified.

5. Develop protection and detection measures

The outcome of the senior management's risk assessment and subsequent company's cyber security strategy should be a reduction in risk, if needed. At a technical level, this would include the necessary actions to be implemented to establish and maintain an agreed level of cyber security.

Special attention should be given when there has been no control over who has access to the onboard systems. This could, for example, happen during drydocking, layups or when taking over a new or existing ship. In such cases, it is difficult to know if malicious software has been left in the onboard systems. It is recommended that sensitive data is removed from the ship and reinstalled on returning to the ship. Where possible, systems should be scanned for malware before prior to use. OT systems should be tested to check that the functionalities are still intact.

It is critical to identify how to manage cyber security on board and to delegate responsibilities to the master, responsible officers and maybe the company security officer.

Cyber security protection measures may be technical and focused on ensuring that onboard systems are designed and configured to be resilient to cyber attacks. Protection measures may also be procedural and should be covered by company policies, safety management procedures, security procedures and access controls. Both technical and procedural controls should be compatible with the confidentiality, integrity and availability (CIA) model for protecting data and information.

It is recognised that technical cyber security controls may be more straightforward to implement on a new ship than on an existing ship. Consideration needs be given to only implement technical controls that are practical and cost effective, particularly on existing ships.

Implementation of cyber security controls should be prioritised, focusing first on those measures, or combinations of measures, which offer the greatest benefit.

5.1 Technical protection measures

The Centre for Internet Security (CIS) provides guidance on measures[11] that can be used to address cyber security vulnerabilities. The protection measures comprise of a list of Critical Security Controls (CSC) that are prioritised and vetted to ensure that they provide an effective approach for companies to assess and improve their defences. The CSCs include both technical and procedural aspects.

The below mentioned examples of CSCs have been selected as particularly relevant to equipment and data onboard ships[12].

[11] CIS, Critical Security Controls for Effective Cyber Security, available at www.cisecurity.org/critical-controls.cfm

[12] Stephenson Harwood (2015), Cyber Risk

Limitation to and control of network ports, protocols and services

Access lists to network systems can be used to implement the company's security policy. This ensures that only appropriate traffic will be allowed via a controlled network or subnet, based on the control policy of that network or subnet.

It should be a requirement that routers are secured against attacks and unused ports should be closed to prevent unauthorised access to systems or data.

Configuration of network devices such as firewalls, routers and switches

It should be determined which systems should be attached to controlled or uncontrolled[13] networks. Controlled networks are designed to prevent any security risks from connected devices by use of firewalls, security gateways, routers and switches. Uncontrolled networks may pose risks due to lack of data traffic control and they should be isolated from controlled networks, as direct internet connection makes them highly prone to infiltration by malware. For example:

- Networks that are critical to the operation of a ship itself, should be controlled. It is imperative that these systems - have a high level of security.
- Networks that provide suppliers with remote access to navigation and other OT system software on onboard equipment, should also be controlled. These networks may be necessary for suppliers to allow upload of system upgrades or perform remote servicing. Shoreside external access points of such connections should be secured to prevent unauthorised access.
- Other networks, such as guest access networks, may be uncontrolled, for instance those related to passenger recreational activities or private internet access for crew. Normally, any wireless network should be considered uncontrolled.

Onboard networks should be partitioned by firewalls to create safe zones. 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. See annex 2 of these guidelines for more information on shipboard networks and also refer to ISO/IEC 62443.

Physical security

Security and safety critical equipment and cable runs should be protected from unauthorised access. Physical security is a central aspect of cyber security[14].

[13] In accordance with EC 61162-460:2015: Maritime navigation and radiocommunication equipment and systems - Digital interfaces - Part 460: Multiple talkers and multiple listeners - Ethernet interconnection - Safety and security

[14] See also the ISPS Code

Detection, blocking and alerts

Identifying intrusions and infections is a vital part of the controls. A baseline of network operations and expected data flows for users and systems should be established and managed so that cyber incident alert thresholds can be established. Key to this will be the definition of roles and responsibilities for detection to ensure accountability. Additionally, a company may choose to incorporate an Intrusion Detection System (IDS) system or an Intrusion Prevention System (IPS) into the network or as part of the firewall. Some of their main functions include identifying threats/malicious activity and code, and then logging, reporting and attempting to block the activity. Further details concerning IDS and IPS can be found in annex 2 of these guidelines. Ensure that dedicated onboard personnel can understand the alerts and their implications. Incidents detected should be directed to an individual or service provider, who is responsible for acting on this type of alert.

Satellite and radio communication

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.

When establishing an uplink connection for ships' navigation and control systems to shore-based service providers, consideration should be given in 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 on board. At the access point for this traffic, it is necessary to provide data security, firewalling and a dedicated "last-mile" connection.

When using a Virtual Private Network (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. However, it is not sufficient to have either onshore filtering of traffic or firewalls/security inspection/blocking gateways on the ship, because both types are needed and supplement each other to achieve a sufficient level of protection.

Producers 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.

Wireless access control

It should be ensured that wireless access to networks on the ship is limited to appropriate authorised devices and secured using a strong encryption key, which is changed regularly.

Malware detection

Scanning software that can automatically detect and address the presence of malware in systems onboard should be regularly updated.

As a general guideline, onboard computers should be protected to the same level as office computers ashore. Anti-virus and anti-malware software should be installed, maintained and updated on all personal work-related computers onboard. This will reduce the risk of these computers acting as attack vectors towards servers and other computers on the ship's network. The decision on whether to rely on these defence methods should take into consideration how regularly the scanning software will be able to be updated.

Secure configuration for hardware and software

Only senior officers should be given administrator profiles so that they can control the set up and disabling of normal user profiles. User profiles should be restricted to only allow the computers, workstations or servers to be used for the purposes for which they are required. User profiles should not allow the user to alter the systems or install and execute new programs.

Email and web browser protection

Email communication between ship and shore is a vital part of a ship's operation. Appropriate email and web browser protection serves to:

- protect shoreside and onboard personnel from potential social engineering
- prevent email being used as a method of obtaining sensitive information
- ensure that the exchange of sensitive information via email or by voice is appropriately protected to ensure confidentiality and integrity of data, for example protecting by encryption
- prevent web browsers and email clients from executing malicious scripts.

Some best practices for safe email transfer are: email as zip or encrypted file when necessary, disable hyperlinks on email system, and avoid using generic email addresses and ensure the system has configured user accounts.

Data recovery capability

Data recovery capability is the ability to restore a system and/or data from a secure copy or image thereby allowing the restoration of a clean system. Essential information and software-adequate backup facilities should be available to ensure it can be recovered following a cyber incident.

Retention periods and restore scenarios should be established to prioritise which critical systems need quick restore capabilities to reduce the impact. Systems that have high data availability requirements should be made resilient. OT systems, which are vital to the safe navigation and operation of the ship, should have backup systems to enable the ship to quickly and safely regain navigational and operational capabilities after a cyber incident. More detail on recovery can be found in chapter 7 of these guidelines.

Application software security (patch management)

Critical safety and security updates should be provided to onboard systems. These updates or patches should be applied correctly and in a timely manner to ensure that any flaws in a system are addressed before they are exploited by a cyber attack.

5.2 Procedural protection measures

Procedural controls are focused on how personnel use the onboard systems. Plans and procedures that contain sensitive information should be kept confidential and handled according to company policies. Examples for procedural actions can be:

Training and awareness

Training and awareness is the key supporting element to an effective approach to cyber safety and security as described in these guidelines and summarised in figure 1.

The internal cyber threat is considerable and should not be underestimated. Personnel have a key role in protecting IT and OT systems but can also be careless, for example by using removable media to transfer data between systems without taking precautions against the transfer of malware. Training and awareness should be tailored to the appropriate levels for:

- onboard personnel including the master, officers and crew
- shoreside personnel, who support the management and operation of the ship.

These guidelines assume that other major stakeholders in the supply chain, such as charterers, classification societies and service providers, will carry out their own best-practice cyber security protection and training. It is advised that owners and operators ascertain the status of cyber security preparedness of their third-party providers as part of their sourcing procedures for such services.

An awareness programme should be in place for all onboard personnel, covering at least the following:

- 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)
- 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 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 if a possible cyber incident is in progress (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 anti-malware, 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.

Further, applicable personnel should know the signs when a computer has been compromised. This may include the following:

- an unresponsive or slow to respond system
- unexpected password changes or authorised users being locked out of a system
- unexpected errors in programs, including failure to run correctly or programs running unexpectedly

- unexpected or sudden changes in available disk space or memory
- emails being returned unexpectedly
- unexpected network connectivity difficulties
- frequent system crashes
- abnormal hard drive or processor activity
- unexpected changes to browser, software or user settings, including permissions.

And, nominated personnel should be able to understand reports from IDS systems, if used. This list is not comprehensive and is intended to raise awareness of potential signs, which should be treated as possible cyber incidents.

Access for visitors

Visitors such as authorities, technicians, agents, port officials, and owner representatives should be restricted with regard to computer access whilst on board. Unauthorised access to sensitive OT network computers should be prohibited through clearly marked physical barriers. If access to a network by a visitor is required and allowed, then it should be restricted in terms of user privileges. Access to certain networks for maintenance reasons should be approved and co-ordinated following appropriate procedures as outlined by the company/ship operator.

If a visitor requires computer and printer access, an independent computer, which is air-gapped from all controlled networks, should be used. To avoid unauthorised access, removable media blockers should be used on all other physically accessible computers and network ports.

Upgrades and software maintenance

Hardware or software that is no longer supported by its producer or software developer will not receive updates to address potential vulnerabilities. For this reason, the use of hardware and software, which is no longer supported, should be carefully evaluated by the company as part of the cyber risk assessment.

Relevant hardware and software installations on board should be updated to maintain a sufficient security level. Procedures for timely updating of software may need to be put in place taking into account the ship type, speed of internet connectivity, sea time, etc. Software includes computer operating systems, which should also be kept up to date.

Additionally, a number of routers, switches and firewalls, and various OT devices will be running their own firmware, which may require regular updates and so should be addressed in the procedural requirements.

Effective maintenance of software depends on the identification, planning and execution of measures necessary to support maintenance activities throughout the full software lifecycle. An industry standard[15] to ensure safe and secure software maintenance has been developed. It specifies requirements for all stakeholders involved in software maintenance of shipboard equipment and associated integrated systems. The standard covers on board, on shore and remote software maintenance.

Anti-virus and anti-malware tool updates

In order for scanning software tools to detect and deal with malware, they need to be updated. Procedural requirements should be established to ensure updates are distributed to ships on a timely basis and that all relevant computers on board are updated.

Remote access

Policy and procedures should be established for control over remote access to onboard IT and OT systems. Clear guidelines should establish who has permission to access, when they can access, and what they can access. Any procedures for remote access should include close co-ordination with the ship's master and other key senior ship personnel.

All remote access occurrences should be recorded for review in case of a disruption to an IT or OT system. Systems, which require remote access, should be clearly defined, monitored and reviewed periodically.

Use of administrator privileges

Access to information should only be allowed to relevant authorised personnel.

Administrator privileges allow full access to system configuration settings and all data. Users logging into systems with administrator privileges may enable existing vulnerabilities to be more easily exploited. Administrator privileges should only be given to appropriately trained personnel who have a need, as part of their role in the company or on board, to log into systems using these privileges. In any case, use of administrator privileges should always be limited to functions requiring such access.

User privileges should be removed when the people concerned are no longer on board. User accounts should not be passed on from one user to the next using generic usernames. Similar rules should be applied to any onshore personnel with remote access to systems on ships when they change role and no longer need access.

In a business environment, such as shipping, access to onboard systems is granted to various stakeholders. Suppliers and contractors are a risk because they often have both intimate knowledge of a ship's operations and often full access to systems.

[15] See: Industry standard on software maintenance of shipboard equipment by BIMCO and CIRM (Comité International Radio-Maritime)

To protect access to confidential data and safety critical systems, a robust password policy should be developed[16]. Passwords should be strong and changed periodically. The company policy should address the fact that over-complicated passwords, which must be changed too frequently, are at risk of being written on a piece of paper and kept near the computer.

Physical and removable media controls

Transferring data from uncontrolled systems to controlled systems represents a major risk of introducing malware. Removable media can be used to bypass layers of defences and can be used to attack systems that are otherwise not connected to the internet. A clear policy for the use of such media devices is essential; it must ensure that media devices are not normally used to transfer information between un-controlled and controlled systems.

There are, however, situations where it is unavoidable to use these media devices, for example during software maintenance. In such cases, there should be a procedure in place to require checking of removable media for malware and/or validating legitimate software by digital signatures and watermarks.

Policies and procedures relating to the use of removable media should include a requirement to scan any removable media device in a computer that is not connected to the ship's controlled networks. If it is not possible to scan the removable media on board, eg the laptop of a maintenance technician, then the scan could be done prior to boarding with the result and timing duly documented. Companies should consider notifying ports and terminals about the requirement to scan removable media prior to permitting the uploading of files onto a ship's system. This scanning should be carried out when transferring the following file types:

- cargo files and loading plans eg container ship BAPLIE files
- national, customs, and port authority forms
- bunkering and lubrication oil forms
- ship's stores and provisions lists
- engineering maintenance files.

This list represents examples and should not be seen as exhaustive.

Equipment disposal, including data destruction

Obsolete equipment can contain data which is commercially sensitive or confidential. The company should have a procedure in place to ensure that the data held in obsolete equipment is properly destroyed prior to disposing of the equipment, ensuring that vital information cannot be retrieved.

[16] More information can be found in NIST publication SP 800-63-3 Digital Identity Guidelines

Obtaining support from ashore and contingency plans

Ships should have access to technical support in the event of a cyber attack. Details of this support and associated procedures should be available on board. Please refer to Chapter 6 of these guidelines for more information about contingency planning.

6. Establish contingency plans

When developing contingency plans for implementation onboard ships, it is important to understand the significance of any cyber incident, particularly for IT and OT systems and prioritise response actions accordingly.

Any cyber incident should be assessed in accordance with the CIA model (see chapter 4) to estimate the impact on operations, assets etc. In most cases, a loss of IT systems on board, including a data breach of confidential information, will be a business continuity issue and should not have any impact on the safe operation of the ship. In the event of a cyber incident affecting IT systems only, the priority may be the immediate implementation of an investigation and recovery plan.

The loss of OT systems may have a significant and immediate impact on the safe operation of the ship. Should a cyber incident result in the loss or malfunctioning of OT systems, it will be essential that effective actions are taken to ensure the immediate safety of the crew, ship and protection of the marine environment. In general, appropriate contingency plans for cyber incidents, including the loss of critical systems and the need to use alternative modes of operation, should be addressed by appropriate operational and emergency procedures included in the safety management system. Some of the existing procedures in the ship's safety management system will already cover such cyber incidents.

The safety management system will already include procedures for reporting accidents or hazardous situations and define levels of communication and authority for decision making. Where appropriate, such procedures should be amended to reflect communication and authority in the event of a cyber incident.

The following is a non-exhaustive list of the actions in response to the type of cyber incidents, which should be addressed in contingency plans on board:

- loss of availability of electronic navigational equipment or loss of integrity of navigation related data
- loss of availability or integrity of external data sources, including but not limited to GNSS
- loss of essential connectivity with the shore, including but not limited to the availability of Global Maritime Distress and Safety System (GMDSS) communications
- loss of availability of industrial control systems, including propulsion, auxiliary systems and other critical systems, as well as loss of integrity of data management and control
- the event of a ransomware or denial or service incident.

It is important that onboard personnel understand that the loss of OT systems due to a cyber incident must be treated like any other equipment failure. Furthermore, it is important to ensure that a loss of equipment or reliable information due to a cyber incident does not make existing emergency plans and procedures redundant. It is crucial that contingency plans, and related information, are available in a non-electronic form as some types of cyber incidents can include the deletion of data and shutdown of communication links.

There may be occasions when responding to a cyber incident may be beyond the competencies on board or at head office due to the complexity or severity of such incidents. In these cases, external expert assistance may be required (for example post event forensic analysis and clean-up).

7. Respond to and recover from cyber security incidents

It is important to understand that cyber incidents may not disappear by themselves. If for example the ECDIS has been infected with malware, starting up the back-up ECDIS may cause another cyber incident. It is, therefore, recommended to plan how to carry out the cleaning and restoring of infected systems.

Knowledge about previous identified cyber incidents should be used to improve the response plans of all ships in the company's fleet and an information strategy for such incidents may be considered.

7.1 Effective response

A team, which may include a combination of onboard and shore-based personnel and/or external experts, should be established to take the appropriate action to restore the IT and/or OT systems so that the ship can resume normal operations. The team should be capable of performing all aspects of the response.

An effective response should at least consist of the following steps:

1. **Initial assessment:** To ensure an appropriate response, it is essential that the response team find out:
   - how the incident occurred
   - which IT and/or OT systems were affected and how
   - the extent to which the commercial and/or operational data is affected
   - to what extent any threat to IT and OT remains.

2. **Recover systems and data:** Following an initial assessment of the cyber incident, IT and OT systems and data should be cleaned, recovered and restored, so far as is possible, to an operational condition by removing threats from the system and restoring software. The content of a recovery plan is covered in section 7.2.

3. **Investigate the incident:** To understand the causes and consequences of a cyber incident, an investigation should be undertaken by the company, with support from an external expert, if appropriate. The information from an investigation will play a significant role in preventing a potential recurrence. Investigations into cyber incidents are covered in section 7.3.

4. **Prevent a re-occurrence:** Considering the outcome of the investigation mentioned above, actions to address any inadequacies in technical and/or procedural protection measures should be considered, in accordance with the company procedures for implementation of corrective action.

When a cyber incident is complex, for example if IT and/or OT systems cannot be returned to normal operation, it may be necessary to initiate the recovery plan alongside onboard contingency plans. When this is the case, the response team should be able to provide advice to the ship on:

- whether IT or OT systems should be shut down or kept running to protect data
- whether certain ship communication links with the shore should be shut down
- the appropriate use of any advanced tools provided in pre-installed security software
- the extent to which the incident has compromised IT or OT systems beyond the capabilities of existing recovery plans.

7.2 Recovery plan

Recovery plans should be available in hard copy on board and ashore. The purpose of the plan is to support the recovery of systems and data necessary to restore IT and OT to an operational state. To ensure the safety of onboard personnel, the operation and navigation of the ship should be prioritised in the plan. The recovery plan should be understood by personnel responsible for cyber security. The detail and complexity of a recovery plan will depend on the type of ship and the IT, OT and other systems installed on board.

As explained in section 5.1, a data recovery capability is a valuable technical protection measure. Data recovery capabilities are normally in the form of software backup for IT data. The availability of a software backup, either on board or ashore, should enable recovery of IT to an operational condition following a cyber incident.

Recovery of OT may be more complex especially if there are no backup systems available and recovery may involve assistance from ashore. Details of where this assistance is available and by whom, should be part of the recovery plan, for example by proceeding to a port to obtain assistance from a service engineer.

If qualified personnel are available on board, more extensive diagnostic and recovery actions may be performed. Otherwise, the recovery plan will be limited to obtaining quick access to technical support.

7.3 Investigating cyber incidents

Investigating a cyber incident can provide valuable information about the way in which a vulnerability was exploited. Companies should, wherever possible, investigate cyber incidents affecting IT and OT on board in accordance with company procedures. A detailed investigation may require external expert support.

The information from an investigation can be used to improve the technical and procedural protection measures on board and ashore. It will also provide the wider maritime industry with a better understanding of maritime cyber risks. Any investigation should result in[17]:

- a better understanding of the potential cyber risks facing the maritime industry both on board and ashore
- identification of lessons learned, including improvements in training to increase awareness
- updates to technical and procedural protection measures to prevent a recurrence.

7.4 Losses arising from a cyber incident

For insurers, the term “cyber” includes many different aspects and it is important to distinguish between them and their effects on insurance cover. Also, it is important to note that according to the general understanding of insurers, there is no systemic risk to ships arising from a cyber incident and the impact of an incident is expected to be most likely confined to a single ship.

Companies will be aware that specific non-marine insurance cover may be available to cover data loss and the resulting fines and penalties resulting from equipment failure.

Companies should be able to demonstrate that they are acting with reasonable care in their approach to managing cyber risk and protecting the ship from any damage that may arise from a cyber incident.

Cover for property damage

Generally, in many markets offering marine property insurance, the policy may cover loss or damage to the ship and its equipment caused by a shipping incident such as grounding, collision, fire or flood, even when the underlying cause of the incident is a cyber incident. It may be noted that currently in some markets exclusion clauses for cyber attacks exist. If the marine policy contains an exclusion clause for cyberattacks, the loss or damage will not be covered.

Companies are recommended to check with their insurers / brokers in advance whether their policy covers claims caused by cyber incidents and/or by cyber attacks.

Guidelines for the market have been published, in which marine insurers are recommended to ask questions about company cyber security awareness and non-technical procedures. Companies should, therefore, expect a request for non-technical information regarding their approach to cyber security from insurers.

The limited data on the frequency, severity of loss or probability of physical damage resulting from a cyber incident, represents a challenge and means that standard pricing is not available.

[17] Based on CREST, Cyber Security Incident Response Guide, Version 1

Cover for liability

It is recommended to contact the P&I Club for detailed information about cover provided to shipowners and charterers in respect of liability to third parties (and related expenses) arising from the operation of ships.

An incident caused, for example by malfunction of a ship’s navigation or mechanical systems because of a criminal act or accidental cyber attack, does not in itself give rise to any exclusion of normal P&I cover.

It should be noted that many losses, which could arise from a cyber incident are not in the nature of third-party liabilities arising from the operation of the ship. For example, financial loss caused by ransomware, or costs of rebuilding scrambled data would not be identified in the coverage.

Normal cover, in respect of liabilities, is subject to a war risk exclusion and cyber incidents in the context of a war or terror risk, will not normally be covered.

Annex 1. Target systems, equipment and technologies

This annex provides a summary of potentially vulnerable systems and data onboard ships to assist companies with assessing their cyber risk exposure. Vulnerable systems, equipment and technologies may include:

Communication systems

- integrated communication systems
- satellite communication equipment
- Voice Over Internet Protocols (VOIP) equipment
- wireless networks (WLANs)
- public address and general alarm systems.

Bridge systems

- integrated navigation system
- positioning systems (GPS, etc.)
- Electronic Chart Display Information System (ECDIS)
- Dynamic Positioning (DP) systems
- systems that interface with electronic navigation systems and propulsion/manoeuvring systems
- Automatic Identification System (AIS)
- Global Maritime Distress and Safety System (GMDSS)
- radar equipment
- Voyage Data Recorders (VDRs)
- other monitoring and data collection systems.

Propulsion and machinery management and power control systems

- engine governor
- power management
- integrated control system
- alarm system
- emergency response system.

Access control systems

- surveillance systems such as CCTV network
- Bridge Navigational Watch Alarm System (BNWAS)
- Shipboard Security Alarm Systems (SSAS)
- electronic “personnel-on-board” systems.

Cargo management systems

- Cargo Control Room (CCR) and its equipment
- level indication system
- valve remote control system
- ballast water systems
- water ingress alarm system.

Passenger servicing and management systems

- Property Management System (PMS)
- electronic health records
- financial related systems
- ship passenger/seafarer boarding access systems
- infrastructure support systems like domain naming system (DNS) and user authentication/authorisation systems.

Passenger-facing networks

- passenger Wi-Fi or LAN internet access
- guest entertainment systems
- passenger Wi-Fi or Local Area Network (LAN) internet access, for example where onboard personnel can connect their own devices[18]
- guest entertainment systems.

[18] This is not considered as Bring Your Own Device (BYOD). Devices are not used to access protected information. They can only be used for an individual’s personal, non-company, use

Core infrastructure systems

- security gateways
- routers
- switches
- firewalls
- Virtual Private Network(s) (VPN)
- Virtual LAN(s) (VLAN)
- intrusion prevention systems
- security event logging systems.

Administrative and crew welfare systems

- administrative systems
- crew Wi-Fi or LAN internet access, for example where onboard personnel can connect their own devices.

Annex 2. Onboard networks

A secure network depends on the IT/OT set up onboard the ship, and the effectiveness of the company policy based on the outcome of the risk assessment. Control of entry points and physical network control on an existing ship may be limited because cyber security had not been considered during the ship's construction. It is recommended that network layout and network control should be planned for all new buildings.

Direct communication between an uncontrolled and a controlled network should be prevented. Furthermore, several protection measures should be added:

- implement network separation and/or traffic management
- manage encryption protocols to ensure correct level of privacy and commercial communication
- manage use of certificates to verify origin of digitally signed documents, software or services.

In general, only equipment or systems that need to communicate with each other over the network should be able to do so. The overriding principle should be that the networking of equipment or systems is determined by operational need.

Physical layout

The physical layout of the network should be carefully considered. It is important to consider the physical location of essential network devices, including servers, switches, firewalls and cabling. This will help restrict access and maintain the physical security of the network installation and control of entry points to the network.

Network management

Any network design will need to include an infrastructure for administering and managing the network. This may include installing network management software on dedicated workstations and servers providing file sharing, email and other services to the network.

Network segmentation

Onboard networks should normally accommodate the following:

1. necessary communication between OT equipment
2. configuration and monitoring of OT equipment
3. onboard administrative and business tasks including email and sharing business related files or folders

4. recreational internet access for crew and/or passengers.

Effective network segmentation is a key aspect of “defence in depth”. OT, IT and public networks should be separated or segmented by appropriate protection measures. The protection measures used may include, but are not limited to an appropriate combination of the following:

- a perimeter firewall between the onboard network and the internet
- network switches between each network segment
- internal firewalls between each network segment
- Virtual Local Area Networks (VLAN) to host separate segments.

In addition, each segment should have its own range of Internet Protocol (IP) addresses. Network segmentation does not remove the need for systems within each segment to be configured with appropriate network access controls and software firewalls and malware detection.

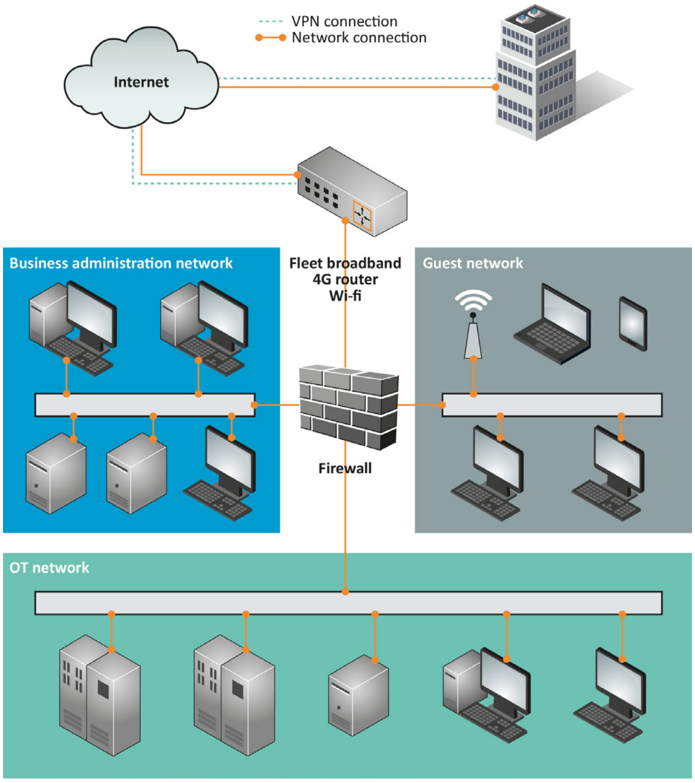


Figure 2. Example of an onboard network

In the example shown, the network has been segmented using a perimeter firewall, which supports three VLANs.

1. The OT Network containing equipment and systems, that performs safety critical functions
2. The IT network containing equipment and systems, that performs administrative or business functions

3. A crew and guest network, providing uncontrolled internet access.

Considerations should be made on how to maximise the security of the switches themselves. To achieve the highest level of security, each network should use a different hardware switch. This will minimise the chance of an attacker jumping between networks due to misconfiguration or by acquiring access to the configuration of a switch.

A correctly configured and appropriate firewall is an essential element of the proper segmentation of a network installation. The onboard installation should be protected by at least a perimeter firewall to control traffic between the internet and the onboard network. To prevent any unintended communication taking place, the firewall should be configured by default to deny all communication. Based on this configuration, rules should be implemented. The rules should be designed to allow passage of data traffic that is essential for the intended operation of that network.

For example, if a specific endpoint receives updates from the internet, the rule should allow the specific endpoint to connect specifically to the server handling the specific update service. Enabling general internet access to a specified endpoint for updates is bad practice.

Uncontrolled networks like a crew or passenger network should not be allowed any communication with the controlled networks. The uncontrolled network should be considered as unsafe as the internet since the devices connecting to it are unmanaged, their security status (antivirus, updates, etc.) is unknown and their users could be acting maliciously, intentionally or unintentionally.

Monitoring data activity

It is essential to monitor and manage systems to be aware of the networks’ status and to detect any unauthorised data traffic. Logging should be implemented in the firewall and ideally in all network-attached devices so that in case of a breach, the responsible person can trace back the source and methodology of the attack. This will help to secure the network from any similar attacks in the future.

A network Intrusion Detection System (IDS) or Intrusion Protection System (IPS) can alert the system administrator in real-time of any attacks to the network systems. The IDS and IPS inspect data traffic, entry points or both to identify known threats or to reject traffic, which does not comply with the security policy. An IPS should comply with the latest industry best practices and guidelines.

It is recommended to place a sensor on the internet-facing segment, because the public servers are a visible target to attackers. Another sensor should be placed behind the firewall, to monitor traffic between the internet and the internal network. An IDS/IPS sensor could also be placed by a remote-access segment, for instance a Virtual Private Network (VPN).

Secure running environment

Normally referred to as a sandbox, a secure running environment provides additional protection against cyber threats by isolating executable software from the underlying operating system. This prevents unauthorised access to the operating systems, on which the software is running. The sandbox enables software to be run under a specific set of rules and this adds control over processes and computer resources. Therefore, the sandbox prevents malicious, malfunctioning or untrusted software from affecting the rest of the system.

Annex 3. Glossary

Access control is selective limiting of the ability and means to communicate with or otherwise interact with a system, to use system resources to handle information, to gain knowledge of the information the system contains or to control system components and functions.

Back door is a secret method of bypassing normal authentication and verification when accessing a system. A back door is sometimes created by hidden parts of the system itself or established by separate software.

Bring your own device (BYOD) allows employees to bring personally owned devices (laptops, tablets, and smart phones) to the ship and to use those devices to access privileged information and applications for business use.

Cyber attack is any type of offensive manoeuvre that targets IT and OT systems, computer networks, and/or personal computer devices attempting to compromise, destroy or access company and ship systems and data.

Cyber incident is an occurrence, which actually or potentially results in adverse consequences to an onboard system, network and computer or the information that they process, store or transmit, and which may require a response action to mitigate the consequences.

Cyber risk management means the process of identifying, analysing, assessing, and communicating a cyber- related risk and accepting, avoiding, transferring, or mitigating it to an acceptable level; taking into consideration the costs and benefits of actions taken by stakeholders.

Cyber system is any combination of facilities, equipment, personnel, procedures and communications integrated to provide cyber services; examples include business systems, control systems and access control systems.

Defence in breadth is a planned, systematic set of activities that seek to identify, manage, and reduce exploitable vulnerabilities in IT and OT systems, networks and equipment at every stage of the system, network, or sub-component life cycle. Onboard ships this approach will generally focus on network design, system integration, operations and maintenance.

Defence in depth is an approach which uses layers of independent technical and procedural protection measures to protect IT and OT on board.

Executable software includes instructions for a computer to perform specified tasks according to encoded instructions.

Firewall is a logical or physical break designed to prevent unauthorised access to IT infrastructure and information.

Firmware is software imbedded in electronic devices that provides control, monitoring and data manipulation of engineered products and systems. They are normally self-contained and not accessible to user manipulation.

Flaw is unintended functionality in software.

Intrusion Detection System (IDS) is a device or software application that monitors network or system activities for malicious activities or policy violations and produces reports to a management station.

Intrusion Prevention Systems (IPSs), also known as Intrusion Detection and Prevention Systems (IDPSs), are network security appliances that monitor network and/or system activities for malicious activity.

Local Area Network (LAN) is a computer network that interconnects computers within a limited area such as a home, ship or office building, using network media.

Malware is a generic term for a variety of malicious software which can infect computer systems and impact on their performance.

Operational technology (OT) includes devices, sensors, software and associated networking that monitor and control onboard systems.

Patches are software designed to update software or supporting data to improve the software or address security vulnerabilities and other bugs in operating systems or applications.

Phishing refers to the process of deceiving recipients into sharing sensitive information with a third-party.

Principle of least privilege refers to the restriction of user account privileges only to those with privileges that are essential to perform its intended function.

Producer is the entity that manufactures the shipboard equipment and associated software.

Recovery refers to the activities after an incident to restore essential services and operations in the short and medium term and fully restore all capabilities in the longer term.

Removable media is a collective term for all methods of storing and transferring data between computers. This includes laptops, USB memory sticks, CDs, DVDs and diskettes.

Risk assessment is the process which collects information and assigns values to risks for informing priorities, developing or comparing courses of action, and informing decision making.

Risk management is the process of identifying, analysing, assessing and communicating risk and accepting, avoiding, transferring or controlling it to an acceptable level considering associated costs and benefits of any actions taken.

Sandbox is an isolated environment, in which a program may be executed without affecting the underlying system (computer or operating system) and any other applications. A sandbox is often used when executing untrusted software.

Service provider is a company or person who provides and performs software maintenance.

Social engineering is a method used to gain access to systems by tricking a human into revealing confidential information.

Software whitelisting means specifying the software which may be present and active on an IT or OT system.

Virtual Local Area Network (VLAN) is the logical grouping of network nodes. A virtual LAN allows geographically dispersed network nodes to communicate as if they were physically on the same network.

Virtual Private Network (VPN) enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network, thereby benefiting from the functionality, security and management policies of the private network.

Virus is a hidden, self-replicating section of computer software that maliciously infects and manipulates the operation of a computer program or system.

Wi-Fi is all short-range communications that use some type of electromagnetic spectrum to send and/or receive information without wires.

Annex 4. Organisations and companies behind the guidelines

The following organisations and companies have participated in the development of these guidelines:

BIMCO

Chamber of Shipping of America (CSA)

Cobham SATCOM

COLUMBIA Shipmanagement Ltd

Cruise Lines International Association (CLIA)

CyberKeel

Inmarsat

International Association of Dry Cargo Shipowners (INTERCARGO)

International Association of Independent Tanker Owners (INTERTANKO)

International Chamber of Shipping (ICS)

International Union of Maritime Insurance (IUMI)

Maersk Line

Naftomar Shipping and Trading

NCC Group

Oil Companies International Marine Forum (OCIMF)

SOFTimpact Ltd

Templar Executives

United States Maritime Resource Center (USMRC)

Wilhelmsen Group

Zodiac Maritime Ltd