**Components of national cyber security arrays in the civil maritime sector**

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This article presents examples of various methods used in cyber security arrays in the civil maritime sector in selected countries. In recent years, there has been progress in developing civil maritime cyber security arrays in a number of countries that are advanced in cyber security.[[2]](#footnote-2) This trend has been reinforced, in part, by international and local cyber events and attacks.[[3]](#footnote-3) Cyber security has even become part of the maritime strategies of some countries operating in the maritime domain.[[4]](#footnote-4)

Different countries have established a variety of cyber security arrays in the maritime sector, with the goal of managing the risk to critical infrastructure and other facilities. These include, for example, maritime cybersecurity operations centers for ports and platforms for sharing information and facilitating coordination within the sector and with other sectors. Several countries are adopting cyber regulation that includes the maritime sector. Other related activity includes training and raising awareness, publishing directives, introducing standards, creating R&D infrastructure and fostering international cooperation.

Due to the limited scope of the article, it presents only some of the maritime cyber security arrays methods applied in the selected countries: Singapore, the Netherlands, Canada, Denmark and the United States. These countries were selected because they play an important role in the global maritime sector and/or because they are developing national maritime cyber arrays. It should be noted that the capability, operational quality and efficiency of the arrays differ from one country to the next. The article concludes by outlining the main components in existing cyber arrays; these components are also recommended by international guides on cyber security.

**Singapore’s maritime sector**

The civilian maritime sector is an important component in Singapore’s economy and accounted for 7 percent of the country’s GDP in 2017 and about 170,000 jobs.[[5]](#footnote-5) Singapore is located in the Straits of Malacca and Singapore (SOMS), a critical strategic route in the global maritime transportation system. Every year, almost half of all global commercial maritime cargo and about 70 percent of Asia’s oil imports pass through these two straits.[[6]](#footnote-6) The Port of Singapore ranks second in the world in container traffic.[[7]](#footnote-7) The cyber strategy of Singapore stresses the importance of defending maritime activity.[[8]](#footnote-8) The Cyber Security Agency of Singapore (CSA) works with the Maritime and Port Authority (MPA) of Singapore to protect the civilian maritime sector.

The Maritime Cybersecurity Operations Center (MSOC) in Singapore began operations in May 2019, monitoring and coordinating all of the critical information infrastructure in the maritime sector.[[9]](#footnote-9) The MSOC enables the MPA to work with critical information infrastructure operators to investigate cyber threats and events in the maritime sector. Plans call for connecting the MSOC to the MPA’s Port Operations Control Centre (POCC), with the goal of facilitating a rapid and comprehensive response to cyber events.[[10]](#footnote-10)

With respect to the training of personnel in cyber security, a new and more comprehensive course is being developed in cooperation with the Singapore Shipping Association and the Singapore Polytechnic. The course is designed to train personnel in cyber risk management, cyber security counter-measures and other subjects.[[11]](#footnote-11) In addition, Singapore is conducting activities aimed at raising awareness of maritime cyber security, including seminars for both the private and public sectors.[[12]](#footnote-12)

The Cybersecurity Act that went into effect in August 2018 provides broad powers to the Commissioner of Cybersecurity and other officials appointed by the commissioner or by the relevant minister. The delegated powers facilitate the gathering and sharing of information, investigation and more. The law establishes cyber security requirements for essential infrastructure in the maritime sector. This includes infrastructure for monitoring and managing shipping, the operation of various types of terminals, refueling infrastructure, rescue operations and more.[[13]](#footnote-13)

The Maritime Cybersecurity Research Program, which focuses on the protection of shipboard systems, will be carried out through cooperation between the MPA, institutions of higher education in Singapore and the Singapore Maritime Institute (SMI).[[14]](#footnote-14)

International collaboration between Singapore and other countries also includes the sharing of professional information on the protection of infrastructure. For example, a memorandum on cyber security cooperation was signed with the Netherlands in 2016.[[15]](#footnote-15) Another example is the hosting of an international forum for safety of navigation and environmental protection in the Singapore and Malacca Straits, which also addresses cyber security.[[16]](#footnote-16) The MPA is planning to establish international cooperation between parallel authorities with the goal of sharing information on threats and cyber events.[[17]](#footnote-17)

The maritime sector was included in national cyber exercises managed by the Cyber Security Agency of Singapore in 2017 and 2019. The exercises tested the resilience of the maritime sector in a variety of cyber scenarios. The simulations included other critical sectors, with the goal of testing the preparedness for major cyber events, including inter-sectoral cooperation.[[18]](#footnote-18)

**The maritime sector in the Netherlands – the Rotterdam and Amsterdam ports**

The Netherlands’ Network and Information Systems Security Act, pursuant to the European Union’s NIS Directive (EU) 2016/1148, went into effect in 2018.[[19]](#footnote-19) The law requires providers of an essential service, including those in the maritime sector, to meet cyber security requirements. It authorizes government ministries or the national Computer Security Incident Response Team (CSIRT), according to the circumstances, to require reporting on cyber events. Additional delegated powers relate to investigation, auditing, sanctions, etc.[[20]](#footnote-20)

The **Port of Rotterdam** is ranked first in Europe in volume of container traffic and eleventh in the world.[[21]](#footnote-21) The port is an important component in the Netherlands’ economy and in Europe’s commercial maritime traffic.[[22]](#footnote-22) In 2017, almost half of the commercial traffic in the port (by cargo weight) served Europe and about one quarter served Asia.[[23]](#footnote-23) A law enacted in 2018 defines the port as a provider of an essential service, thus obligating it to fulfill a number of cyber security requirements.[[24]](#footnote-24)

The port operates in cooperation with the country’s National Cyber Security Center (NCSC). Several cyber security bodies have been created at the port. One example is a cyber notification desk that receives reports of major cyber events; the desk has been operating as part of the port’s operations center since 2018. Companies operating in the port that are subject to the ISPS code[[25]](#footnote-25) or EU regulations[[26]](#footnote-26) are required to report major cyber events to the notification desk and in some cases to other entities as well. These events relate to situations that affect the security of traffic in the port, the entry and exit of ships, and the implementation of the port security plan.[[27]](#footnote-27)

In 2016, a port cyber resilience officer was appointed and a plan of action was formulated. The officer’s area of responsibility includes training, raising awareness and managing cyber risks. To this end, committees were established to deal with the various aspects of cyber security, such as legislation and exercises. The cyber resilience officer works in cooperation with law enforcement agencies, municipal authorities and other bodies.[[28]](#footnote-28) The port carries out cyber exercises and maintains a staff of cyber security experts who are responsible for protecting the port infrastructure.

Cyber security conferences have been held to raise awareness and improve cyber training for businesses that operate in the port. The port offers a program of cyber security assistance for small businesses, which includes online training and tools that help to identify cyber weaknesses. The assistance is based on the realization that small businesses are important to the port’s activity and are connected to important port systems, but do not have the resources to deal with complex cyber issues and therefore may constitute a weak link.[[29]](#footnote-29)

The **Port of Amsterdam** initiated a program to upgrade cyber security in 2018. It presented e-learning modules about information security with the aim of raising awareness of the issue among workers and other stakeholders. The port recruited an information security officer and established a cyber security hotline.[[30]](#footnote-30) The hotline receives voluntary reports in addition to compulsory reports from entities that are subject to the ISPS code and are required to fulfill a list of conditions published by the port.

The Port of Amsterdam cooperates in this area with the NCSC, the Port of Rotterdam, the Digital Trust Center (DTC) and other entities. In addition, the port has initiated a program for sharing information with the private and public sectors, including law enforcement agencies. It also sponsors public information events in cyber security in order to raise awareness and to provide professional information.[[31]](#footnote-31)

**Canada’s maritime sector**

A government forum called the Maritime Cyber Risk Project constitutes the basis for cooperation between ten different bodies from various ministries. The forum’s goal is to propose possible solutions to cyber threats in the maritime sector.[[32]](#footnote-32)

The Canadian Cyber Incident Response Center (CCIRC) operates a digital platform for disseminating information to critical infrastructure sectors and for enhancing cooperation. The platform facilitates the distribution of information according to levels of security classification. The CCIRC is available to assist in the management of cyber events in critical infrastructure, including in the maritime sector, and operates support programs to help entities in the private sector carry out risk assessments.[[33]](#footnote-33)

Entities subject to the maritime security regulations are required to include cyber security in their assessment and security programs. In certain cases, there is a requirement to report a cyber event to government bodies.[[34]](#footnote-34)

Transport Canada, a federal institution, is responsible for establishing a cooperative network for conducting a sectoral risk assessment on an annual basis.[[35]](#footnote-35) In 2016, Transport Canada published a document on cyber security best practices for the maritime sector.[[36]](#footnote-36) Similar documents were published in 2016-2017 for the maritime sector in the United Kingdom. The documents present recommended methods for cyber security in port infrastructure and shipping.[[37]](#footnote-37) France also published a series of documents in 2016-2018 on maritime cyber security[[38]](#footnote-38) and, in 2019, the European Union Agency for Cybersecurity (ENISA) published best practices for cybersecurity in ports.[[39]](#footnote-39)

Canada’s Marine Security Operations Centers (MSOC) are responsible for managing events in the maritime domain. The centers assist in the assessment of risk to ports, vessels and maritime facilities. Each year, about 7,000 risks assessments are carried out for vessels entering Canada’s maritime domain.[[40]](#footnote-40)

The centers bring together various governmental bodies involved in the maritime domain. The centers focus on identifying and reporting maritime activity that poses a potential threat to security and safety.[[41]](#footnote-41) In recent years, the area of cyber security has been added to the centers’ responsibilities.

**Denmark – Implementation of a maritime cyber security strategy**

Denmark’s national cyber strategy cites the maritime sector as one of the country’s critical infrastructures. A cyber strategy document that specifically addresses the maritime sector was published in January 2019 and some of its recommendations have already been implemented.[[42]](#footnote-42) The largest container shipping company in the world—A.P. Moller-Maersk—is headquartered in Denmark. A major cyber attack against Maersk in 2017 harmed the company and disrupted port operations in a number of countries.[[43]](#footnote-43)

The Centre for Cyber Security (CFCS) provides assistance to the Danish Maritime Authority (DMA). The cyber strategy document states that the DMA should serve as a liaison between the maritime sector and the CFCS. Cooperation between the bodies includes the analysis and sharing of information on threats and assistance in risk evaluations for the maritime sector.[[44]](#footnote-44) The first assessment was released to the public in 2017 and included recommendations for cyber security.[[45]](#footnote-45)

In June 2018, a maritime cybersecurity unit was established in the DMA. The unit is responsible for implementing the measures prescribed in the strategy document, and serves as an advisory body, a communication center for the maritime sector and a source of expertise in the DMA. The unit is also responsible for coordinating an action plan with the maritime sector in areas such as regulation, training and raising awareness.[[46]](#footnote-46) It participates in a cyber forum that includes all of the cyber units in Denmark’s critical sectors. The goal of the forum, which operates in partnership with the CFCS, is to share information on threats and cyber events, and to promote cooperation between the various sectors.[[47]](#footnote-47)

The DMA published an order on maritime cyber security that went into effect in February 2019. The order implements part of the European Union’s NIS directive on cyber security (Directive (EU) 2016/1148)[[48]](#footnote-48) and includes a number of obligations that apply to DMA-appointed operators of a maritime service. For example, in certain cases, there is an obligation to report a cyber event to the DMA and to the CFCS. Another requirement is to become certified as meeting international cyber security standards within two years of receiving an appointment from the DMA.[[49]](#footnote-49)

The DMA works to foster cooperation in the cyber security field with other countries.[[50]](#footnote-50) A cyber security forum that includes all of the authorities that have any direct influence on the maritime sector in Denmark is slated to be inaugurated in 2020-2021. The forum will prepare plans for responding to cyber events and emergencies, coordinate cyber exercises in the sector and more.[[51]](#footnote-51)

**The United States – The maritime sector and the Port of Los Angeles**

The U.S. Coast Guard, which is responsible for cyber security in the American maritime sector, published its strategy for cyber security in 2015.[[52]](#footnote-52) There is extensive regulation of maritime security in the U.S.[[53]](#footnote-53) Under certain conditions specified in the regulations, there is an obligation to report a cyber event to the Coast Guard, which operates the National Response Center (NRC) that deals with these reports.[[54]](#footnote-54) The Department of Homeland Security’s National Cybersecurity and Communications Integration Center (NCCIC) provides assistance to critical infrastructure. This includes transportation infrastructure, which encompasses the maritime sector.[[55]](#footnote-55) The NCCIC operates a Hunt and Incident Response Team (HIRT) to assist organizations that have been attacked and request its intervention.[[56]](#footnote-56) In addition, the Maritime and Port Security Information Sharing and Analysis Organization (MPS-ISAO), a non-profit partnership of the private and public sectors, serves as a platform for sharing information in the maritime sector.[[57]](#footnote-57)

The Port of Los Angeles, ranked first in container traffic in the U.S., operates the Cyber Security Operations Center (CSOC). The CSOC is responsible for port infrastructure and is considered the first of its kind in the country. The port reported in 2019 that it is the only one in the country that is certified as meeting the cyber standard ISO 27001.[[58]](#footnote-58) A plan to establish a Cyber Resilience Center to serve all of the entities connected to the port was initiated in 2019. The new center is expected to serve as a platform for sharing information and professional knowledge, coordinating operations and more.[[59]](#footnote-59)

**Conclusion and recommendations**

This article highlights several key components in national cyber security arrays in the civilian maritime sector. The following summary of these components is not an exhaustive list of all possibilities. There are variations that can be tailored to the specific conditions and characteristics of each country. Wise use of the various tools, while establishing an optimal cyber security structure in the maritime sector, can support the effective management of the cyber domain.

A number of international guides offer professional insights that can assist in the creation of sectoral cyber security arrays. The arrays presented in this article make use of tools that are generally similar to those presented in the guides. The NATO Cooperative Cyber Defense Centre of Excellence (NATO CCDCOE), the European Union Agency for Cybersecurity (ENISA) and the International Telecommunications Union (ITU) are among the organizations that have published such guides.[[60]](#footnote-60)

Here is a list of recommended components of a national cyber security array in the civilian maritime sector. These components are used in arrays worldwide and presented in the leading international cyber security guides:

**Structure of the arrays: Main bodies and entities**

1. A national multi-sector cyber security body

Serves as a professional resource for assisting the entity responsible for cyber security in the maritime sector. This body provides professional information, guidance, management of multi-sector exercises, a platform for cross-sectoral cooperation, etc.

1. A maritime cyber security body

Usually operates within a government entity responsible for the civilian maritime sector. This body interacts with the various entities in the maritime sector. Its functions may include implementation of programs for training and raising awareness, management of exercises in the sector, assistance and consultation, assessment of sectoral risks and threats, publishing of directives, etc.

In addition, a cyber security operations center that operates in the maritime sector can facilitate the ongoing management and rapid response to any cyber activity in the sector. The center can provide a full picture of what is happening in the sector, can coordinate the information received from the various sources, can manage the response to major cyber events, etc.

1. Cyber security entities in essential and non-essential maritime infrastructure

Ports and maritime facilities should have a cyber security officer and a cyber security team if necessary. There is also an option to establish a cyber desk, a cyber security operations center, etc.

**Training and awareness-raising programs**

Training and awareness-raising programs among various audiences, such as workers in government entities connected to the maritime sector, workers at essential infrastructure and any others active in the maritime sector. The programs are usually tailored to each group.

**Risk assessment**

Risk assessment for the maritime sector, specific infrastructure and facilities, etc.

**Exercises in the maritime sector and in a multi-sectoral framework**

1. Participation of the sectoral cyber body and/or essential infrastructure participants in national cross-sectoral exercises.
2. Exercises in the maritime sector, including a number of entities or the entire sector.
3. Exercises at infrastructure facilities and in specific bodies.

**Cooperation programs: Coordination, planning, guidance and sharing of information**

1. A multi-sectoral forum

Participation in a national cross-sectoral forum for coordination and cooperation, including representatives of the body responsible for the maritime sector.

1. Forum of government entities and/or essential entities

Forum for coordination and cooperation that brings together all government bodies and critical infrastructure in the maritime sector. In some cases, the creation of a government forum that includes only the governmental entities connected to maritime cyber security is recommended.

1. Forum for all stakeholders in the civilian maritime sector

A forum for coordinating and sharing information and capabilities, bringing together all of the entities in the maritime sector.

**International cooperation**

Cooperation with other countries, private and public bodies and international institutions in areas such as research, training, coordination of activity, intelligence, etc.

**Research programs**

A research program that includes academia, the government and the private and public sectors in the areas of cyber security in the maritime sector.

**Regulation that provides means of enforcement, capabilities and tools**

Legislation that provides efficient tools for managing cyber security in the maritime sector, while creating appropriate checks and balances. The legislation can include a legal foundation for establishing cyber bodies in the array. In addition, it can specify obligations such as the duty to report defined cyber events to the relevant government bodies. It is also recommended to establish a cyber entity with powers for gathering information, issuing directives and/or standards, supervision and oversight, investigation and management of cyber events in certain cases, etc.

**Continuity and recovery plans**

Preparing and implementing continuity and recovery plans for the maritime sector in general, and specifically for bodies and infrastructure in the maritime sector.

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