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# Ship Traffic and Port Operation Information Critical Infrastructure Network

**Keywords**

Critical infrastructure, ship traffic, port operation, information systems, VTS, DGPS, BALPIE, EDI, THETIS, MarSSIS

**Abstract**

The goal of the article is to define the Ship Traffic and Port Operation Information Critical Infrastructure Network. In first step, the basic information about EMSA are introduced. There are two main information systems for safety of the ships: SeaSafeNet and THETIS, which are presented in details. Furthermore, the ship information systems operated in Poland are introduced and described. These systems are: PHICS, MarSSiES and DGPS. Besides, the port operation systems in Baltic Sea Region are presented. According to the knowledge the 166 Ship Traffic and Operation Information Critical Infrastructure Network components are proposed.

## 1. Introduction

Following the loss of the tanker ERIKA off the French coast in 1999, the European Union adopted several directives aimed at preventing accidents at sea and marine pollution. Directive 2002/59/EC adopted by the Parliament and the Council on 27 June 2002 (later amended by Directive 2009/17/EC) established a Community vessel traffic monitoring and information system "with a view to enhancing the safety of efficiency of maritime traffic, improving the response of authorities to incidents, accidents or potentially dangerous situations at sea, including search and rescue operations, and contributing to a better prevention and detection of pollution by ships" [1].
Parallel pursuant to Regulation 1406/2002/EC of 27 June 2002, the European Maritime Safety Agency (EMSA) was also being established. In 2003, it was decided that the Agency should be responsible for setting-up and operating the new vessel traffic and monitoring system, which would be called SafeSeaNet. The system finally became fully operational in 2009.

## 2. Ship Traffic Information System

The core of the SafeSeaNet architecture is the EIS (European Index Server). It is the secure and reliable system within a "hub and spoke" network (including authentication, validation, data transformation and logging) which sends requests to, and receives notifications and responses from, approved users (*Figure 1*).

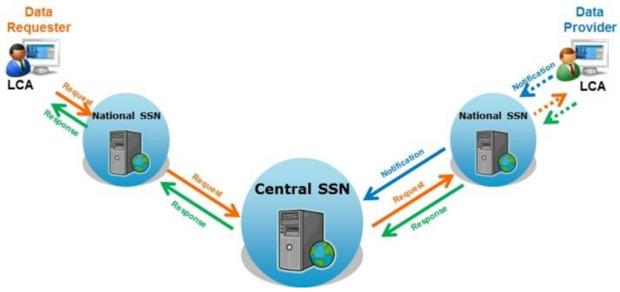


*Figure 1.* SafeSeaNet architecture [1]

One of the features of the EIS is the ability to locate and retrieve information on vessels related to one Member State in response to a query or request made by another. Despite the amount of information exchanged, the main notification reports submitted to SafeSeaNet are as follows [1]:

- Ship Notifications: voyage and cargo information. Notifications are based on two types of message. Automatic Identification System (AIS) messages are sent automatically by the ships through very high frequency (VHF) radio signals, and received by coastal stations within range. Mandatory ship reporting systems (MRS) can be established by governments, with approval from the International Maritime Organization, for certain types of vessel transiting through defined areas. MRS messages are sent by ship masters to coastal stations. Information includes ship identification, course, speed, and cargo.
- Port Notifications: These are used to notify SafeSeaNet when vessels arrive and depart from ports. The estimated time of arrival, actual time of arrival, actual time of departure and the number of persons on board are included in the message.
- Hazmat Notifications: These are used to notify SafeSeaNet that vessels are carrying hazardous materials (dangerous or polluting goods) on board, and that the data provider has detailed information on these goods.
- Incident Reports: These are used to provide SafeSeaNet with information on incidents involving ships. These might be related to ship safety and sea worthiness (e.g. collisions, groundings, equipment failures), the environment (e.g. pollution incidents) or other pre-defined categories (e.g. banned ships, ships not reporting according to rules).
- Waste Notifications: These are provided to users via SafeSeaNet in compliance with the EU Reporting Formalities Directive, and they allow interested parties to find out the different types of waste on board, and when and where they are to be discharged.
- Security Notifications: These are also provided to users via SafeSeaNet in compliance with the EU Reporting Formalities Directive, and they provide information on security issues that relate, in particular, to avoiding the ship being used as a weapon.

## 2.1. THETIS

To give the possibility to realize main goal of EMSA, the THETIS system was introduced. This is the information system that supports the new Port State Control inspection regime (NIR) according to the new Directive 2009/16/EC on Port State Control and its four implementing regulations, Directive 99/35/EC on ro-ro ferries and high-speed passenger crafts, Directive 2009/17/EC on vessel traffic monitoring, Directive 2009/15/EC on Recognised Organisations and the related Regulation (EC) No 319/2009 and, from July 2013, Directive 2009/20/EC on insurance for maritime claims and Regulation (EC) No 392/2009 on liability for the carriage of passengers [2]. The system serves both the EU Community and the wider region of the Paris Memorandum of Understanding on PSC (Paris MOU) which includes Canada, Iceland, Norway and the Russian Federation. The working name for the system is THETIS - who, fittingly, was a goddess of the sea in mythology. To facilitate planning of inspections, the new system is linked to the Community's SafeSeaNet system. SafeSeaNet provides information on ships in, or expected at, all ports of the Member States. THETIS indicates which ships have priority for inspection and allows the results of inspections to be recorded. Via THETIS these reports are made available to all port State control authorities in the Community and the Paris MOU. THETIS also interfaces with a number of other maritime safety-related databases including those of the EU-recognised classification societies, Community and national information systems and other port State control regimes so as to exchange data and provide a full picture for the inspector. Inspection results are also available through a public website.

Today, 18 000 inspections per year are recorded in the system by 600 authorised users from 27 connected countries. Each day more than 3 000 arrivals at any port in the region of Paris MoU are recorded in the system, collected through SafeSeaNet [2].

In Poland, according to the Regulation of the Minister of Transport, Construction and Maritime, dated 12.04.2012, on the National Ship Traffic Monitoring System and Transmission of Information, introduced the National SafeSeaNet System with following components:

- Technical infrastructure;
- Coordinator of the SafeSeaNet;
- National users of SafeSeaNet.

The technical infrastructure contains:

- Vessel traffic monitoring subsystem with following elements:
  - short- and long-range coastal radars,
  - Automatic Identification System (AIS) base stations,
  - Long-Range Identification and Tracking System (LRIT);
- Information subsystem consists of:
  - Polish Harbours Information and Control System (PHICS);
  - Maritime Safety and Security Information Exchange System (MarSSIES).

## 2.2. PHICS

According to information from [4], Polish Harbours Information & Control System (PHICS) is a nationwide electronic system exchange documents related to the supervisory functions and control over maritime transportation, performed by the Poland Maritime Administration. The solution is based on the system central-located in the data center and remote access users from anywhere in the country and around the world using the public Internet.

"Maritime Safety & Security Information Exchange System" - MarSSIES is profesional application developed for special demands and needs of Maritime Office in Gdynia and in general Polish Maritime Administration. MarSSIES is probably the only such an aplication in Europe and implemented first time in 2003. System serves as a platform distributing information between operational services cooperating in range of vessel traffic safety. Distribution is held between Maritime Operations Centre of the Polish Navy, National Navigation Warning Services Coordinator from Hydrographic Office of the Polish Navy and Control Centre of Polish Border Guard. In future a group of users will include Maritime Offices in Szczecin and Slupsk, Maritime Rescue Coordination Centre and Maritime Search and Rescue Service, Voivode Crisis Management Centres, Maritime Mobile Service of Customs Chamber, Harbour Masters' Offices and expert units in Maritime Offices.

MarSSIES organizes and manages exchange of the information essential for vessel traffic safety via tele-network and enables event procession in accordance with ISPS Code. User defines types of events and describes procedures for each one (event support). Every new event can be initiated by an operator ('manually') or automatically as a result of receiving data from other systems, databases or readings registered by specified devices.

When a new event occurs, it is being processed by the system in accordance with defined procedure, e.g. system notifies specified receivers or waits for making and registering applicable decisions, etc. Maritime Safety & Security Information Exchange System - MarSSIES [4].

MarSSIES application is based on map presentation (compatible with S-52 standard), which includes Polish marine areas and land areas under liability of Polish Maritime Administration Services, along with Baltic Sea area in general *Figure 2*). Presentation on the map uses S-57 standard map cells and enables placing additional operational information in multilayer system. All data presented on the map is stored in system database. Map presentation interactively cooperates with event (information package) generation system, thus:

- event information call enables automatic presentation of attached graphic layer,
- selecting object on the presentation map enables generation of event directly related to the object,
- user can use library of objects (AIS, VTS- IPS),
- a call displays or distinguishes chosen object on the presentation map,
- the map can present vessels' movement basing on information from AIS system.

System uses following data:

- AIS stream from Polish AIS shore stations,
- data from VTS system for the Gulf of Gdańsk,
- navigation warnings and Notices to Mariners received from Hydrographic Office of the Polish Navy,
- weather forecasts developed by The Institute of Meteorology and Water Management, n
- notifications received by operators of particular services,
- hydrologic and meteorological data sent by automatic sensors from the Gulf of Gdańsk area.

## 2.3. DGPS System

Marine Differential Global Positioning System (DGPS) is a ground-based augmentation system providing higher accuracies than standard GPS. DGPS is intended for coastal navigation and precise geographical positioning in restricted waters by using differential correction broadcasting received by radio from the shore based reference stations. This operation is based on assumption that most of the factors that cause inaccuracies in the GPS position measurement are basically common (the same) in a limited geographical area. By receiving the GPS signal at a known and constant position, one can determine the measurement errors and cancel them at DGPS receiver. The principle of DGPS is a technique that allows to obtain more accurate position measurements than the standard single GPS receiver. With a second receiver, i.e. base station (reference station)-the steady receiver at an exactly surveyed point allows it to generate differential corrections to common satellites. This in turn allows to eliminate most errors that influence position accuracy.

The second navigation receiver must be capable of receiving these corrections by the radio communication link or via the internet. The differential stations (reference stations) operate on these bases. They receive signals from GPS satellites, calculate the common errors and generate corrections to be sent to nearby GPS navigational receivers. Of course, these GPS receivers must be capable of receiving such corrections by a dedicated radio link. The maritime DGPS system is also known worldwide under the name of IALA DGPS. It is the IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) organization that have developed and disseminated its principles as well as ITU (International Telecommunication Union) that assigned LF/MF beacon frequencies worldwide.

Differential corrections and integrity information from maritime stations are broadcast in RTCM SC-104 protocol. This data can be used both in real time or in post processing mode. The beacon system in Europe uses LF/MF band 283,5-315 kHz with digital MSK modulation with rates 100 or 200 bits per second.

The Maritime DGPS system in Poland is one of main navigation services established and coordinated by Maritime Office in Gdynia. It has been provided support of coastal navigation for: hydrography, navigation marking, sea exploration and offshore engineering. Its standard was implemented in 1995 as a result of many years of Polish activity in the IALA, which the Maritime Office in Gdynia is a national member. DGPS service is the only radio navigation system available and used worldwide. It relies primarily on GPS satellite constellation and can provide a geographical position accuracy of 1-3 meters and integrity warnings within the range of up to 300 km from the shore reference base station. Polish Maritime DGPS consists of two shore base stations (Rozewie and Dziwnow) and the central monitoring station in Gdynia, providing coverage of well over 150 km from the Polish coast. Both stations are monitored remotely on a continuous basis to manage their operation and to inform users and technical service about current status or any malfunctions in its operation. DGPS-PL has been completely redesigned during the period 2007-2011 to gain modern technology and integration to complex aids to navigation monitoring system provided by Maritime Office in Gdynia within the EU project of National Maritime Safety System (KSBM).

The Baltic Marine DGPS network covers whole Baltic Sea (*Figure 2*) and give very high accuracy for many marine applications in shipping, transport, safety, bathymetry and many others. The key feature of this system is its integrity function which for users is best information if the system is in proper operational state.


*Figure 2.* Baltic Marine DGPS [4]

## 3. Ship Port Operation Information System

The importance of ports in Baltic Sea Region is increasing every year. There are open the new liner services that generate the ship traffic and port operations. In 2014 the TOP 10 Baltic container ports handled almost 7.83 mln TEU. It is very important to implement the new technologies that enhanced the handling capacity of ports and their revenues.

Due to the need to improve the customer service nowadays every container terminal in the world use the Electronic Data Interchange (EDI). This is the electronic communication method that provides standards for exchanging data and documents (such as purchase orders, invoices, shipping notices, and many others) via any electronic means by two different companies from different countries. The most commonly used current data exchange standards are:

- BAPLIE - "UN/EDIFACT UNITED NATIONS STANDARD MESSAGE (UNSM) BAYPLAN / STOWAGEPLAN OCCUPIED AND EMPTY LOCATIONS MESSAGE",
- MOVINS - "UN/EDIFACT UNITED NATIONS STANDARD MESSAGE (UNSM) DRAFT STOWAGE INSTRUCTION MESSAGE".

Both are designed by the SMDG (User Group for Shipping Lines and Container Terminals). BAPLIE is used by and between various parties to advise the exact stowage positions of the cargo on board of an ocean vessel. Besides the container number and the exact position on board, general information regarding the containers is also specified such as weight and hazardous cargo class. It therefore gives a "snapshot" of the stowage plan of the containers, both for the current situation and for the situation in the near future, after calling at each of the ports of discharge and loading on the ocean vessel's route.

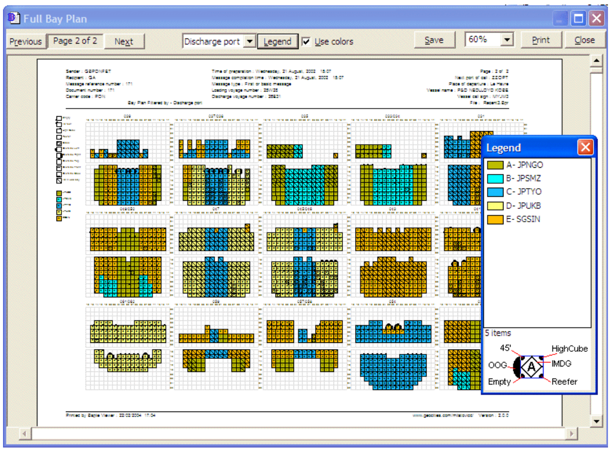


*Figure 3.* Exemplary cargo plan screenshot from Baplie Viewer [8]

The BALPIE message (*Figure 3*) is created by the container Terminal responsible for loading and discharging the ocean vessel using a special module within his "Terminal Operating System" (TOS). During loading the container number is registered by the chief tallyman or by OCR scanning on the loading crane and this is passed on to the TOS. The TOS can then delete the discharged containers from the previous BAPLIE report and add newly loaded containers. The cell position of containers that have been shifted on the ship needs to be modified. The message is then sent to the captain of the vessel (usually an attachment to an e-mail or on a physical carrier such as a USB stick), to the shipping company(ies) concerned and to the hazardous cargo department of the Port Authority's Harbourmaster. Copies are also sent to the next container Terminals the ship will call at. They can upload the data of the BAPLIE message without manual intervention in their stowage planning module and in combination with the loading and discharge instructions a new stowage plan can be drawn up that takes into account the stability of the ship and the position of dangerous cargo on board [9].

The message contains the following information [9]:

- Identification of the ship (via "call sign" or IMO-number)
- Port of loading (preferably with UN/LOCODE)
- Next port of call (preferably with UN/LOCODE)
- Optionally the Terminal code for the next port of call
- ETA next port of call
- List of cargo on board, with specification per container of:
  *Container number*
  *ISO size/type code (e.g. 2210,…)*
  *Empty/Full indication*
  *Weight (gross weight)*
  *Stowage position (BBBRRTT - Bay/Row/Tier, and for Roro the deck needs to be specified too - DD)*
  *Required transport temperature*
  *Dangerous good Class (IMDG Code)*
  *Flashpoint if required*

The MOVINS message is used to transmit information about all activities like discharging, shifting, restowing and loading on a specified means of transport from the operator or owner of the means of transport to any party involved with the operation on this means of transport at a certain place [Manual, 2004]. It is possible transmit a complete or a partial message (after agreement between EDI-partners). Therefore, it is possible to send "MOVINS" for Discharge only, followed by Loading, Restow and Shift.

The handling instructions given in the "MOVINS" message can be apply to the information available in the planning system of the terminal. The details of the vessel, like number of bays and rows/tiers per bay under and on deck, should be known by the planning system of the terminal. This message is to be transmitted in general from the operator/owner of a MoT or a stowage centre to e.g. the terminal operator [7].

## 4. Ship Traffic and Port Operation Information Critical Infrastructure Network

After considering analysis performed in Section 2 and 3 of this paper, we define the Baltic Ship Traffic and Port Operation Information Critical Infrastructure Network (BSTPOICIN) composed of 121 AIS base stations, 27 DGPS stations and 21 port/terminal operation systems listed below:

1. Traffic and port operation information system 1 – AIS Szczecin (TPOIS1), Poland,
2. Traffic and port operation information system 2 – AIS Police (TPOIS2), Poland,
3. Traffic and port operation information system 2 – AIS Swinoujscie (TPOIS3), Poland,
4. Traffic and port operation information system 2 – AIS Kikut (TPOIS4), Poland,
5. Traffic and port operation information system 2 – AIS Niechorze (TPOIS5), Poland,
6. Traffic and port operation information system 2 – AIS Gaski (TPOIS6), Poland,

7. Traffic and port operation information system 2 – AIS Jarosławiec (TPOIS7), Poland,
8. Traffic and port operation information system 2 – AIS Czolpino (TPOIS8), Poland,
9. Traffic and port operation information system 2 – AIS Rozewie (TPOIS9), Poland,
10. Traffic and port operation information system 2 – AIS Hel (TPOIS10), Poland,
11. Traffic and port operation information system 2 – AIS Krynica Morska (TPOIS11), Poland,
12. Traffic and port operation information system 2 – AIS Baltiysk (TPOIS12), Russia,
13. Traffic and port operation information system 2 – AIS Iantarniy (Amber) (TPOIS13), Russia,
14. Traffic and port operation information system 2 – AIS Klaipeda (TPOIS14), Lithuania,
15. Traffic and port operation information system 2 – AIS Liepaja Port (TPOIS15), Latvia,
16. Traffic and port operation information system 2 – AIS Riga (TPOIS16), Latvia,
17. Traffic and port operation information system 2 – AIS Saulkrasti (TPOIS17), Latvia,
18. – 22. Traffic and port operation information systems 18 – 22 – Five AIS base stations in Estonia: TPOIS18 – TPOIS22,
23. – 31. Traffic and port operation information systems 23 – 31 – Nine AIS base stations in Russia: TPOIS23 – TPOIS31,
32. – 59. Traffic and port operation information systems 32 – 59 – Twenty–eight AIS base stations in Finland: TPOIS32 – TPOIS59,
60. – 96. Traffic and port operation information systems 60 – 96 – Thirty–seven AIS base stations in Sweden: TPOIS60 – TPOIS96,
97. – 109. Traffic and port operation information systems 97 – 109 – Thirteen AIS base stations in Denmark: TPOIS97 – TPOIS109,
110. – 121. Traffic and port operation information systems 110 – 121 – Twelve AIS base stations in Germany: TPOIS110 – TPOIS121,
122. Traffic and port operation information system 122 – DGPS base station in Dziwnow (TPOIS122), Poland,
123. Traffic and port operation information system 123 – DGPS base station in Rozewie (TPOIS123), Poland,
124. Traffic and port operation information system 124 – DGPS base station in Baltiysk (TPOIS124), Russia,
125. Traffic and port operation information system 125 – DGPS base station in Kleipada (TPOIS125), Lithuania,
126. Traffic and port operation information system 126 – DGPS base station in Ventospills (TPOIS126), Latvia,
127. Traffic and port operation information system 127 – DGPS base station in Ristna (TPOIS127), Estonia,
128. Traffic and port operation information system 128 – DGPS base station in Narva (TPOIS128), Estonia,
129. Traffic and port operation information system 129 – DGPS base station in Shepelevskiy (TPOIS129), Russia,
130. Traffic and port operation information system 130 – DGPS base station in Klamila (TPOIS130), Russia,
131. Traffic and port operation information system 131 – DGPS base station in Porkkala (TPOIS131), Finland,
132. Traffic and port operation information system 132 – DGPS base station in Turku (TPOIS132), Finland,
133. Traffic and port operation information system 133 – DGPS base station in Mantyluoto (TPOIS133), Finland,
134. Traffic and port operation information system 134 – DGPS base station in Marjaniemi (TPOIS134), Finland,
135. Traffic and port operation information system 135 – DGPS base station in Bjuroklubb (TPOIS135), Sweden,
136. Traffic and port operation information system 136 – DGPS base station in Jarnas (TPOIS136), Sweden,
137. Traffic and port operation information system 137 – DGPS base station in Skutskar (TPOIS137), Sweden,
138. Traffic and port operation information system 138 – DGPS base station in Hjortonsudde (TPOIS138), Sweden,
139. Traffic and port operation information system 139 – DGPS base station in Nynashamn (TPOIS139), Sweden,
140. Traffic and port operation information system 140 – DGPS base station in Hoburg (TPOIS140), Sweden,
141. Traffic and port operation information system 141 – DGPS base station in Holmsjo (TPOIS141), Sweden,
142. Traffic and port operation information system 142 – DGPS base station in Kullen (TPOIS142), Sweden,
143. Traffic and port operation information system 143 – DGPS base station in Gotheborg (TPOIS143), Sweden,
144. Traffic and port operation information system 144 – DGPS base station in Skagen (TPOIS144), Denmark,

145. Traffic and port operation information system 145 – DGPS base station in Blavandshuk (TPOIS145), Denmark,
146. Traffic and port operation information system 146 – DGPS base station in Wustrow (TPOIS146), Germany,
147. Traffic and port operation information system 147 – Mainsail – operation system of BCT Gdynia (TPOIS147), Poland,
148. Traffic and port operation information system 148 – nGen – operation system of GCT Gdynia (TPOIS148), Poland,
149. Traffic and port operation information system 149 – operation system of Baltic Grain Terminal in Gdynia (TPOIS149), Poland,
150. Traffic and port operation information system 150 – Navis – operation system of DCT Gdansk (TPOIS150), Poland,
151. Traffic and port operation information system 151 – operation system in the port Szczecin–Swinoujscie (TPOIS151), Poland,
152. Traffic and port operation information system 152 – operation system in the Port of Aarhus (TPOIS152), Denmark,
153. Traffic and port operation information system 153 – operation system in the Copenhagen–Malmoe Port (TPOIS153), Denmark and Sweden,
154. Traffic and port operation information system 154 – operation system in the Lübecker Hafen–Gesellschaft (TPOIS154), Germany,
155. Traffic and port operation information system 155 – operation system in the Port of Rostock (TPOIS155), Germany,
156. Traffic and port operation information system 156 – operation system in the Port of Tallinn (TPOIS156), Estonia,
157. Traffic and port operation information system 157 – operation system in the Freeport of Riga (TPOIS157), Latvia,
158. Traffic and port operation information system 158 – operation system in the Freeport of Ventspils (TPOIS158), Lithuania,
159. Traffic and port operation information system 159 – operation system in the Klaipeda State Seaport (TPOIS159), Lithuania,
160. Traffic and port operation information system 160 – operation system in the Port of Helsinki (TPOIS160), Finland,
161. Traffic and port operation information system 161 – operation system in the Port of Turku (TPOIS161), Finland,
162. Traffic and port operation information system 162 – operation system in the Port of Hamina–Kotka (TPOIS162), Finland,
163. Traffic and port operation information system 163 – operation system in the Port of Gotheburg (TPOIS163), Sweden,
164. Traffic and port operation information system 164 – operation system in the Port of Lulea (TPOIS164), Sweden,
165. Traffic and port operation information system 165 – operation system in the Port of Stockholm (TPOIS165), Sweden,
166. Traffic and port operation information system 166 – operation system in the Port of Trelleborg (TPOIS166), Sweden.

The BSTPOICIN interactions with Baltic Sea Environment and Other Critical Infrastructures can be expressed by its strong impact on the proper and the efficient functioning of maritime transport. Mainly, it affects the BSCIN and BPCIN. Moreover, BSTPOICIN cooperates with and depends on land critical infrastructures and systems, i.e. electric power grids, computer and internet networks, etc.
The BSTPOICIN interacts strongly with the climate-weather change process, what was partly presented in [5] and will be discussed in details in [6].

## 5. Conclusion

Firstly, the basic information about European Maritime Safety Agency has been introduced.
There are the two main systems operating under EMSA organization, i.e. SeaSafeNet and THETIS, which have been described. Furthermore, the ship traffic and port operation systems used in Poland, i.e. MarSSIS, PHICS, DGPS have been presented.
Besides, the port operation systems in Baltic Sea Region are also introduced.
Following to above information, the Ship Traffic and Port Operation Information Critical Infrastructure Network based on 166 components operating within this area has been proposed.

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