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Maritime ferry critical infrastructure assets and interconnections

Keywords

critical infrastructure, assets, identification, interconnections, interdependencies, maritime ferry

Abstract

This article aims to analyze the problem of maritime ferry critical infrastructure assets and their interconnections identification. As a result, there are distinguished direct assets, auxiliary assets, flow of people, goods and services of the maritime ferry as a component of the shipping critical infrastructure network. Additionally, the identification of interconnections and interdependencies of this critical infrastructures network are identified.

1. Introduction

The critical infrastructure's components are characterized by strong interconnections. In the era of globalization and technological development, the infrastructure elements are increasingly interdependent not only within a system, but also in the dimension of interdependence of systems. The existing network of interconnections makes a violation of critical infrastructure that may result in the impairment of the functioning of other subsystems, and even their damage. Their condition, crew training, traffic safety and a single asset or set of assets protection are influential factors for the whole safety of critical infrastructures.

Every day, the majority of critical infrastructures such as the public transportation systems, among others, depend on the correct networks functioning that support their operations. This article can be also used in the future to identify the network assets that need to be secured, and in case of outages, ensure resilient interconnections. Assets essential to critical infrastructures can severely hamper the functioning of society. Disruptions of critical infrastructure could result in catastrophic loss of life, adverse economic effects and significant harm to public confidence [7].

2. Critical infrastructure assets – basic definitions

The individual critical infrastructure assets are part of a larger interconnected system. The consequences of a system-level failure can far exceed the consequences associated with a single asset. According to the taxonomy enclosed in the report [3], the basic definitions are recalled below:

- An *asset* is any person, facility, material, information, or activity that has a positive value to the critical infrastructure. The asset may have value to an adversary, as well as an owner, although the nature and magnitude of those values may differ. Assets may be categorized in many ways, including people, information, equipment, facilities, and activities or operations [14].
- An *infrastructure asset* is any long-lived resource that is operated as a system or network, such as a sewer collection and water supply system [15].
- *Interconnected critical infrastructures* are those, which have mutually direct and indirect connections between themselves.
- *Interdependent critical infrastructures* are those, which have mutually dependant relationships between themselves interacting at various levels of their complexity.

3.1. Classification of critical infrastructure assets

The different types of assets exhibit different characteristics of the critical infrastructure and can be used for diverse purposes in order to generate future benefits. According to *Figure 1*, critical infrastructure's assets may be categorized and determined as follows: direct assets, auxiliary assets, flow of people, goods and services, cash flow, accessibility and capacity.

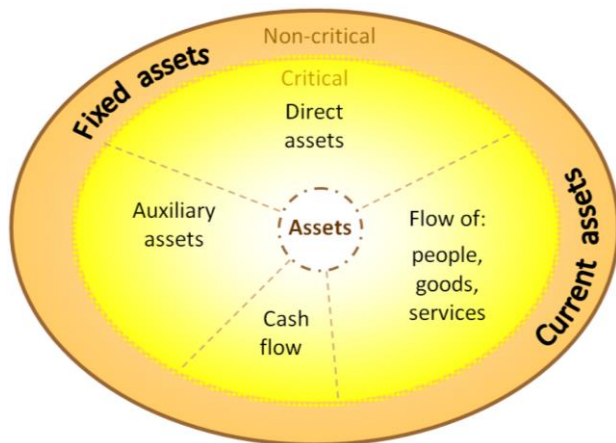


Figure 1. General classification of assets for critical infrastructure in terms of use

3. Maritime ferry assets

3.1. Maritime ferry assets

The considered maritime ferry is a passenger Ro-Ro ship operating at the Baltic Sea between Gdynia and Karlskrona ports on regular everyday line. The general ship characteristics including the vessel tonnage, dimensions, draught, speed, power and capacity are given in *Table 1*.

Table 1. General characteristics of Stena Baltica

Characteristic	Technical data
Tonnage	31.910 GT
Dimensions	Length: 161.80 m, Breadth: 27.61 m Depth: 18.52 m
Draught (max)	6.20 m
Speed (max)	37 km/h (21 knots)
Hull material	Steel
Power	26.320 Bhp; 19.360 Kw
Capacity	1320 passengers, 550 vehicles 120 buses, 1650 m lines

Secondly, based on the information gathered from experts, [6] and from Stena Line Group website [13],

it was possible to identify the maritime ferry critical infrastructure network assets described below.

3.2. Identification of maritime ferry elementary assets

According to the experts' opinion, there are distinguished elementary assets for the maritime ferry technical system. We assume that the ferry is composed of a number of main subsystems illustrated in *Figure 2* and *Figure 3* [4], [9]:

- S_1 – a navigational subsystem,
- S_2 – a propulsion and controlling subsystem,
- S_3 – a loading and unloading subsystem,
- S_4 – a stability control subsystem,
- S_5 – an anchoring and mooring subsystem,
- S_6 – a protection and rescue subsystem,
- S_7 – a social subsystem.

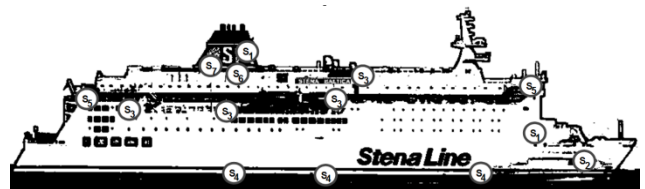


Figure 2. Subsystems having an essential influence on the ferry safety

The strictly technical subsystems S_1 , S_2 , S_3 , S_4 and S_5 , further called the ferry technical system, contain most of the direct assets. The last two subsystems (S_6 and S_7) mostly contain the auxiliary assets. All the fixed assets are expected to keep providing benefit for more than one year. The elementary fixed direct assets of the considered ferry technical system are listed below.

The navigational subsystem S_1 is composed of one general component that is equipped with GPS, AIS, speed log, gyrocompass, magnetic compass, echo sounding system, paper and electronic charts, radar, ARPA, communication system and other subsystems.

The propulsion and controlling subsystem S_2 is composed of:

- the subsystem S_{21} which consist of 4 main engines;
- the subsystem S_{22} which consist of 3 thrusters;
- the subsystem S_{23} which consist of twin pitch propellers;
- the subsystem S_{24} which consist of twin direction al rudders.

The loading and unloading subsystem S_3 is composed of:

- the subsystem S_{31} which consist of 2 remote upper trailer decks to main deck;
- the subsystem S_{32} which consist of 1 remote fore car deck to main deck;

- the subsystem S_{33} which consist of passenger gangway to Gdynia Terminal;
- the subsystem S_{34} which consist of passenger gangway to Karlskrona Terminal.

The stability control subsystem S_4 is composed of:

- the subsystem S_{41} which consist of an anti-heeling system, which is used in port during loading operations;
- the subsystem S_{42} which consist of an anti-heeling system, which is used at sea to stabilizing ships rolling.

The anchoring and mooring subsystem S_5 is composed of:

- the subsystem S_{51} which consist of aft mooring winches;
- the subsystem S_{52} which consist of fore mooring and anchor winches;
- the subsystem S_{53} which consist of fore mooring winches.

The subsystems S_1, S_2, S_3, S_4, S_5 indicated in *Figure 2* are forming a general series safety structure of the ferry technical system presented in *Figure 3*.

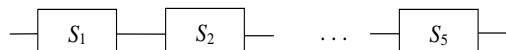


Figure 3. The general scheme of the ferry technical system safety structure

The detailed scheme of these subsystems and components is illustrated in *Figure 4*.

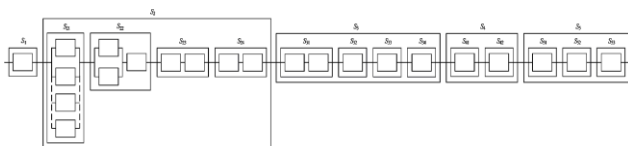


Figure 4. The scheme of the ferry technical system structure

A protection and rescue subsystem S_6 of Stena Baltica vessel mostly carry auxiliary assets. There is 25 per cent overcapacity for on-board safety equipment (i.e. lifeboats, life rafts, life buoys, life jackets and other). Certain vessels have the Marine Evacuation System (MES) – a flexible means of abandoning a vessel which is connected to a platform of life rafts. There is room for everyone with space to spare. In addition, there is fixed and portable fire-extinguishing equipment. The fixed fire-extinguishing system with sprinklers is vital in order to be able to extinguish any fires on board. The vessel also has a maintenance system that generates an alert when it is time to check safety equipment, technical subsystems and other on-board equipment [13].

A social subsystem S_7 consists of a terrace bar, 3 restaurants, on-board shop, cabins for travelling with pet, Wellness Centre, kid's play area and 2 conference rooms for the passengers.

According to the official Stena Line's website [13], the extensive ferry travel assistance features mean that all parts of ferry are accessible to both wheelchair and non-wheelchair users. And, any further assistance can be able to arrange at the port before embarking on the ferry.

Flow of people, goods and services would not be possible if there were no information technology. Technology is often perceived as an asset, although it is probable to impede safety and security operations, particularly when new solutions are launched.

All the assets described in this section generate the cash flow and may bring a positive value to the company that owns the vessel.

4. Maritime ferries' interconnections and interdependencies

The set of ships operating at the Baltic Sea waters at the fixed moment of time (or at the fixed time interval) is called the Baltic Shipping Critical Infrastructure Network (BSCIN) that is particularly described in [2]. The operation process and safety of the shipping critical infrastructure network depends strongly on the individual ships it is composed of operating area within the Baltic Sea region [5].

Stena Line Group is an international transport and travel service company with Europe's route network. It offers a range of frequent ferry travel services to ferry ports in Ireland, England, the Netherlands, Germany, Denmark, France, Sweden, Norway, Poland and Latvia (*Figure 5*). The green line in the figure illustrates cooperation with Gdynia and Karlskrona cities (since 1995). The outcome of the long term company project was the growth of passengers and cargo transport, due to good cooperation and regional promotion. As a result of that, Gdynia and Karlskrona became sister cities. Stena Line operates Europe's most comprehensive route network, which comprises of 18 strategically located ferry routes in Scandinavia, the Irish Sea and the North Sea. Stena Line has a modern fleet including high speed ferries (HSS), traditional combination ferries, RoPax-ferries for freight and passengers, and pure cargo ships [1]. Stena Baltica is a passenger Ro-Ro ship operated in the years 2002-2011 between Karlskrona and Gdynia ports on regular everyday line [9]. The detailed maritime ferry route is illustrated in *Figure 6* [6].

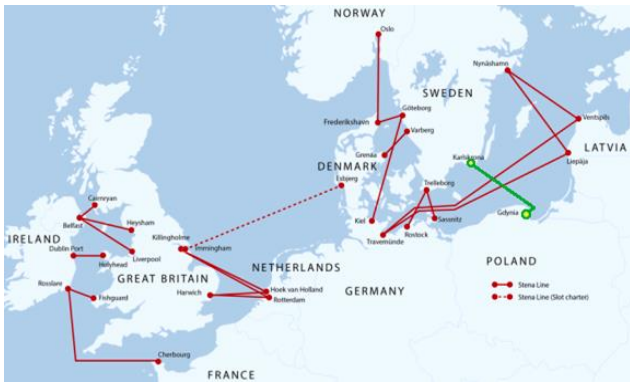


Figure 5. Ferry routes in Scandinavia, around Great Britain and to the Baltic countries, including the considered route between Gdynia and Karlskrona (green line)



Figure 6. Maritime ferry route between Karlskrona and Gdynia ports

As with the traditional aspects of the transportation network, interdependencies also exist between the assets, people, and the facilities in which they reside. The frequency of departures mostly depends on the port of the ship destination. The most popular destinations from Port of Gdynia and the differences in year 2011 and 2014 are shown in Tables 2-3 [11]. The recent (10.02.2016-22.02.2016) vessel arrivals by type in Gdynia and Karlskrona ports are presented in Figures 7-8 [10].

Table 2. Mooring vessels in Gdynia port in 2011

Flag	Antigua-Barbuda, Bahamas, Barbados, Belgium, Belize, Bermuda, Bulgaria , Cambodia, Cayman Islands, China, Cook Islands, Cyprus, Denmark, Dominica , Estonia, Finland, Germany, Gibraltar, Greece , Honduras, Hong Kong, Ireland, Isle of Man, Italy, Latvia, Liberia, Lithuania, Luxembourg, Malta, Marshall Islands, Netherlands, Netherlands Antilles, Norway, Panama, Philippines , Poland, Portugal, Russia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Singapore, Slovakia , Spain, Sweden, Turkey, United Kingdom, Vanuatu
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Berth	Albańskie, Angielskie, Bramowe, Bułgarskie, Czeskie, Dokowe, Duńskie, Falochron BPPP, Fińskie, Francuskie, Gościnne, Greckie , Helskie I-II, Holenderskie, Indyjskie, Islandzkie, Kotwiczowisko Nr 1-3, Kutrowe, Litewskie, Norweskie, Polskie, Południowe, Pomorskie, Portowe , Prezydenta, Rotterdamskie, Rumuńskie, Śląskie, Slipowe , Słowackie , Stanów Zjednoczonych, Stocznia Gdynia, Stocznia Marynarki Wojennej, Stocznia Nauta, Stoczniovców , Suchego Doku, Szwedzkie, Węgierskie, Wendy, XXX Lecia
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Table 3. Mooring vessels in Gdynia port in 2014.

Flag	Antigua-Barbuda, Bahamas, Barbados, Belgium, Belize, Bermuda, China, Croatia , Cyprus, Denmark, Estonia, Finland, Germany, Gibraltar, Hong Kong, Iceland , Ireland, Isle of Man, Italy, Latvia, Liberia, Lithuania, Luxembourg, Malta, Marshall Islands, Netherlands, Netherlands Antilles, Norway, Panama, Poland, Portugal, Russia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Singapore, Sweden, Turkey, United Kingdom, Vanuatu,
Berth	Albańskie, Angielskie, Basen IX-X , Bramowe, Bułgarskie, Czeskie, Dokowe, Duńskie, Falochron BPPP, Fińskie, Francuskie, Gościnne, Helskie I-II, Holenderskie, Indyjskie, Inżyniera Wendy , Islandzkie, Kotwiczowisko Nr 1-3, Kutrowe, Litewskie, Norweskie, Pochylnia , Polskie, Południowe, Pomorskie, Prezydenta, Rotterdamskie, Rumuńskie, Śląskie, Stanów Zjednoczonych, Stocznia Gdynia, Stocznia Marynarki Wojennej, Stocznia Nauta, Suchego Doku, Szwedzkie, Węgierskie, Wendy, Włoskie , XXX Lecia

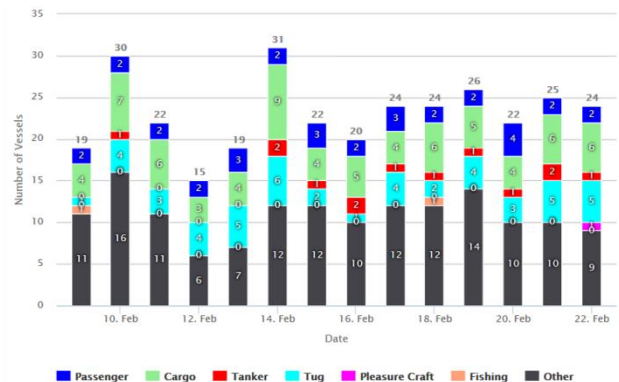


Figure 7. Recent vessel arrivals by type in port of Gdynia (10.02.2016-22.02.2016)

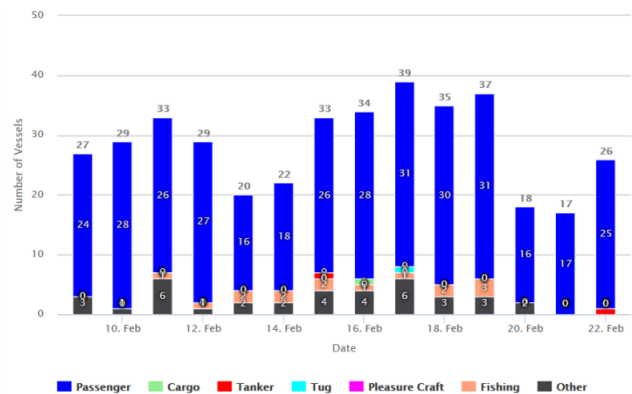


Figure 8. Recent vessel arrivals by type in port of Karlskrona (10.02.2016-22.02.2016)

More than 30 ships make an average of nearly 90 calls to the city annually bringing over 100 000 first-time and repeat visitors. The Port of Gdynia offers space for more than 200 boats and can host 50-60 of 20-meter yachts. Finnlines ferries also offered scheduled ferry services from port of Gdynia on the route Gdynia–Helsinki but there won't be temporarily any passenger traffic. In the meantime Finnlines continues with cargo ro-ro operation of this route. In previous years, there was also Gdynia-Restock route available for the passengers. The schedules ferries (past and previous) interconnections are illustrated in *Figure 9* [12] and the interconnections within the transportation system network of Stena Line Group and the possibilities of further transportation connections are shown in *Figure 10* [13] and *Figure 11* [8].



Figure 9. Interconnections within the transportation system network in Europe (scheduled ferries).

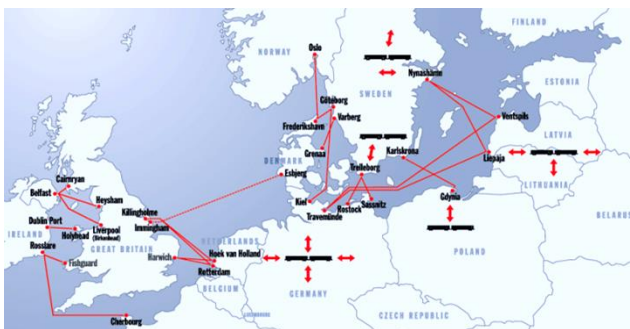


Figure 10. Interconnections within the transportation system network of Stena Line Group and the possibilities of other transportation connections



Figure 11. Stena Baltica transportation system further range interconnections from Karlskrona port

Acknowledgments



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References

- [1] AFerry.com. The World's Leading Ferry Website. (2016), [available at: www.aferry.com/stena-line.html].
- [2] Blokus-Roszkowska, A., Bogalecka M. & Kołowrocki, K. (2016). Critical infrastructure networks at Baltic Sea and its seaside. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars 7, 2*, 7-14.
- [3] EU-CIRCLE Report D1.1-GMU1. (2015). *EU-CIRCLE Taxonomy*.
- [4] EU-CIRCLE Report D1.2-GMU1. (2016). *Identification of existing critical infrastructures at the Baltic Sea area and its seaside, their scopes,*

parameters and accidents in terms of climate change impacts.

- [5] EU-CIRCLE Report D1.4-GMU3. (2016). *Holistic approach to analysis and identification of critical infrastructures within the Baltic Sea area and its surroundings – Formulating the concept of a global network of critical infrastructures in this region (“network of networks” approach).*
- [6] EU-CIRCLE Report D2.1-GMU3. (2016). *Modelling Climate-Weather Change Process Including Extreme Weather Hazards.*
- [7] Government of Canada, National Security, Critical Infrastructure, [available at: <http://www.publicsafety.gc.ca/cnt/ntnl-scrt/crtcl-nfrstrctr/index-en.aspx>].
- [8] Green Cargo, Kurier Kolejowy. (2013), [available at: <http://kurierkolejowy.eu/aktualnosci/17141/karlskrona-inwestuje-w-hub-intermodalny.html>].
- [9] Kolowrocki, K. & Soszynska-Budny, J. (2011). *Reliability and Safety of Complex Technical Systems and Processes: Modeling-Identification-Prediction-Optimization.* Springer, ISBN: 9780857296931.
- [10] MarineTraffic. (2016), [available at: www.marinetraffic.com].
- [11] Maritime Vortal – Maritime companies database. (2016), [available at: <http://www.maritime.com.pl/index-en.php>].
- [12] SeaTours. (2016), [available at: <http://www.seatours.pl/en/ferry-connections/ferries-from-gdynia.html>].
- [13] Stena Line Group website. (2016), [available at: <http://www.stenaline.com/en-GB-corp/corporate>].
- [14] U.S. Department of Homeland Security. (2007). *Transportation Systems: Critical Infrastructure and Key Resources Sector-Specific Plan as input to the National Infrastructure Protection Plan.*
- [15] Zevenbergen, C., Cashman, A., Evelpidou, N., et al. (2011). *Urban Flood Management.* Taylor and Francis.