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Shipping critical infrastructure network

Keywords

critical infrastructure, shipping, Baltic Shipping Critical Infrastructure Network (BSCIN), maritime ferry operation process, Climate-Weather Change Process (C-WCP)

Abstract

In the article there are described shipping density, condition and ship accidents at the Baltic Sea waters. Shipping is gathered in the network of critical infrastructure. Impact of changing climate/weather on that infrastructure is taken into account. The maritime ferry – a passenger Ro-Ro ship operating at the Baltic Sea between Gdynia and Karlskrona ports on regular everyday line is described. Next, the climate-weather impact on the technical system operation and safety of maritime ferry is considered.

1. Shipping density at the Baltic Sea waters

Ships are very important components of the maritime transportation system. Shipping is a maritime segment of the general transportation system. That's why ships are so important components of the critical infrastructure. Their condition, crew training, traffic safety are influential factors for the whole safety of transportation system. Further, 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 dynamic Baltic Shipping Critical Infrastructure Network (BSCIN). The influence of climate change on the BSCIN its safety is crucial. Figures presented in this section show components of a shipping critical infrastructure in the Baltic Sea and its operating conditions.

There are a lot of ships passing Danish Straits and the number varies between 1000-2000 per day. The huge traffic across the Baltic Sea is observed (15% of the world's goods moves on it). The traffic intensity in the region and number of ships recorded by Automatic Identification System (AIS) may be observed in real time throw the Internet (*www.marinetraffic.com*).

According to AIS data from April to October 2014 there were in total 2125 international cruise ship calls (visiting ships in a port) in the Baltic Sea. 1866 of those were intra-Baltic travels, or calls where both the previous port visited and the current port were in the Baltic Sea. In 2014 these international cruise ship voyages involved 7,15 million person days in the Baltic Sea region. The main destinations for cruise ships include St. Petersburg, Copenhagen, Tallinn, Helsinki and Stockholm. The cruising season in the Baltic Sea stretches from late April until October. 70% of cruise ship voyages between two ports in the Baltic Sea lasted from 8 to 20 hours at sea in 2014. Another cluster of voyage durations was between 30 and 42 hours (23% of trips). After trips of more than 30 hours at sea the ships stay mostly in ports in the eastern part of the Baltic Sea (Tallinn, Stockholm, St Petersburg and Helsinki) but also in Copenhagen [18].

The cargo ships are the largest group of vessels type. The overall ship traffic in 2013 decreased compared to the previous year (2012) with roughly 350,000 ship crossings in total in 2013. The decrease in 2013 as well as the previous decrease in 2009 and 2010, especially for cargo ships, is likely due to decreased shipping activity resulting from the economic recession [17].

2. Shipping conditions and ship accidents at Baltic Sea waters

Intense ship traffic is putting a lot of pressure on the Baltic Sea environment, such as accidental pollution, pollution by ship-generated waste, air pollution, and transportation of alien species in ballast water [16].

The Baltic Sea is a particularly difficult sea area to navigate, because of many shallow water areas, narrow straights, large archipelagos, and especially challenging winter conditions. The problem of narrowness and shallowness is seen in accidents statistics. A lot of them occurred in Danish Straits and Finland archipelago.

Winter trafficking is challenging because of the harsh weather conditions, especially because of ice cover. The drifting and ridging of the ice exposes ships to hull damages, as thick ice ridges are difficult to penetrate. Ships might also get stuck in the compressed ice fields. The fact, that during wintertime it is dark almost round the clock, makes winter transportations even more difficult [14]-[15], [20].

There have never been any terrorist strikes in the Baltic Sea, neither have there been large oil accidents. The biggest catastrophe in the Baltic Sea happened in the 1994 when the passenger ferry MV Estonia sunk near the Finnish coast due to a technical failure [22]. The accident climbed 852 lives. On the other hand, the m/s Globe Asimi accident was the most severe accident occured the Baltic Sea pollution. On November 19, 1981, in rough weather conditions, the British tanker loaded with 20,000 tons of oil was leaving the port in Klaipėda when it hit the pier. Most of the oil spilled into the sea (16,000 tons), causing an environmental disaster. The spillage was classified as a medium one, compared to the most tragic sea accident in the world (m/s Atlantic Empress, 287,000 of spilled oil, 1979) [1].

The last two decades data show more than 100 accidents and incidents at the Baltic Sea every year. HELCOM reported approximately 1840 accidents with 1960 vessels at the Baltic Sea in 1989-2013. On average 4.7% of them (in 2004-2013) occurred the sea environment pollution with usually no more than 0.1-1 tones of only oil substances. The pollution with substance other than oil has noted only once since 1996 (a leakage of 0.5 m^3 of orthoxylene in Gothenburg on 13th February 1996) [13].

Beaches, ports and other coastal areas are more threatened areas, because of a lot of sea accidents occurred rather in the coastal waters (such ports – 26% and their approaches – 19%) than open sea areas – 34% in 2013.Of the reported accidents in 2013, 15 took place in ice conditions (specially northern parts of the Baltic Sea). Unfortunately, information on ice conditions was missing for 37% of the reported accidents.

The oil and other chemicals spills in a high sensitivity area cause more damages than the same spill in a low sensitivity one. The Northern Baltic Sea has areas of high sensitivity to damages but low level of ship traffic. When accidents occur they have a great impact because of the ice coverage, making oil and other chemical recovery more challenging. The Danish coasts are generally vulnerable because of the narrow straits and high traffic density. The risk of damage is high around the Danish islands and the Finnish archipelago [21]. Thus, the highest sensitivity is observed on the coast, in archipelagos and in shallow water areas.

The event or an act that take place to instigate an accident is the primary factor in the nature of this accident, called the cause of the accident. The principle cause should be analysed in each case of the accident. The nature of an accident is illustrated by both the cause of the accident and the subsequent consequences resulting from the accident.

To gain a fuller understanding of the nature of vessel accidents both the cause and consequence should be identified and analysed within the study. Most of recorded data indicates that the nature of tanker accidents is organised into four groups, these are as follows:

- operational accidents caused for instance by cargo operations, maintenance, navigation and operational errors,
- non-operational accidents caused for instance by equipment failures and mechanical failures,
- weather related accidents,
- unclassified accidents.

The causes of accidents are:

- cargo operation (it is related to cargo operations or specifically to cargo as a material),
- equipment failure (it is made up of the failure of equipment, including boilers, windlasses, heaters, pumps, hose and hydraulic systems),
- maintenance (an accident occurs due to the act of maintenance or repair,it is heavily influenced by the human element and judgement),
- mechanical failure (it is related to any mechanical failure, specifically engine breakdown or malfunction, as well as steering gear failures),

– navigation (an accident occurs due to the act of navigation, it is heavily influenced by the human element and judgement),
– unclassified (it had no clear or recorded cause, but did have detailed information on the consequence and so were worthwhile retaining in the refined dataset. They were a minority with the data identified, accounting for 4.6% of the total accidents reviewed),
– weather (accidents caused by adverse weather conditions, such as: fog,ice, strong winds, heavy seas or large waves and lightening)

The accident consequences are the results appearing after the accident. The majority of accidents have only one consequence, but a number of them have multiple consequences as would be expected in a variety of different scenarios. The selected consequences of accidents are:

– allision (the act of striking or collision of a moving vessel against a stationary object),
– asphyxiation (crewmembers are asphyxiated by the lack of oxygen or the presence of gas; these accidents involve enclosed spaces or the unexpected presence or release of cargo vapours),
– collision (the act or process of colliding between two moving vessels),
– disabled (the vessel’s propulsion is rendered inoperable by the cause of the accident),
– explosion (a sudden uncontrolled explosion causing damage to the vessel),
– fire (cargo or the vessel is set ablaze by the cause of the accident),
– foundering (the vessel sinks and this consequence may indicate that either the tanker or the other vessel involved in the accident has foundered),
– grounding (the vessel makes contact with the seabed, either temporarily or the duration of the accident),
– man overboard (a crew member falls into the water),
– mooring failure (the loss of mooring lines and / or windlass resulting in the vessel losing station and coming adrift),
– pollution (the loss of a harmful or poisonous substance as classified by the MARPOL convention and related codes),
– stability (the vessel’s stability is compromised by the accident and the vessel lolls or turns over),
– steering gear (a mechanical failure or damage causes the steering gear to become inoperable),
– structural damage / failure (the accident results in significant damage to the vessel, resulting in structural damage / failure or the breaking up of the vessel),
– trapped (this relates to vessels becoming disabled in ice where the vessel becomes stuck fast in ice and is unable to continue on its passage without assistance).

Next, the main accident categories are: collision, contact, grounding and stranding, foundering, capsizing, fire, explosion, loss of hull integrity, flooding, machinery related accidents, payload related accidents, hazardous substance accidents, accidents to personnel, accidents to the general public and shore populations, electrocution, aviation accidents, high probability events, high severity outcomes, low confidence / high uncertainty events.

3. Factors affecting ships operating at the Baltic Sea waters

The influence of hazards related to climate and weather on navigation operation is on of most significant factors. The ship operations that can be affected by climate/weather hazards are:

– navigation on passage (navigating or operating near or through, international or national traffic, coastal traffic short sea shipping traffic, fishing vessels, recreational craft),
– fishing operations (single vessels, paired vessels and others fishing in close proximity, crabbing, trawling, drift nets),
– recreational activities (sail and power cruising or day sailing or racing, personal watercraft e.g. jet skiing, windsurfing, kite surfing and boarding, leisure or sport diving),
– anchoring (routine or emergency anchoring),
– other marine operations close to or within (aggregate dredging, dredging or spoil dumping, commercial diving, construction or servicing or decommissioning or oil and gas or salvage operations, cable laying, pipeline installation, boarding and landing of pilots,
– special events (regattas and competitions).

Other installations operating at the Baltic Sea Area and especially the offshore renewable energy installations (OREI) like wind energy production farms and oil and gas piping have also significant influence on shipping. There are most of them:

– wind turbines (foundation type, transition piece, tower, nacelle, blades, platforms and superstructure fittings),
– floating and fixed wave energy devices,
– floating and fixed tidal energy devices (not appropriate in the Baltic Sea),
– offshore installations (if appropriate: offshore substation, service bases, accommodation bases),
– cables (export cable, inter-turbine cabling),
– sub-sea installations, including anti-scour material,
– wrecks,

– oil and gas installations (existing and projected),
– other offshore renewable energy installations (existing and projected),
– other exclusion or safety zones including areas to be avoided (ATBA),
– fishing grounds,
– dredging and dumping areas,
– diving areas.

The conditions affecting navigation activities not only related to the climate and the climate change but also taking into account other aspects, important from the safety of navigation is:

– weather (restricted visibility by fog, mist, haze, precipitation, wind strength and direction, sea state, icing, light conditions),
– tides and local currents (local currents, tidal streams and heights),,
– time of day (night, dawn, day, dusk),
– circumstances (planning access to shelter, vessel constrained by her draft, vessel engaged in fishing, vessel not under command, vessel restricted in her ability to manoeuvre, scheduled/shuttling vessels),
– electronics (vessels underway with no AIS i.e. non SOLAS craft or with AIS switched off, interference to marine radar, navigation and communications),
– other (overfalls and other local conditions).

A special conditions affecting navigation activities related to the human element (the issue which is very important from the IMO point of view) is: violation, mistakes, lapse, slip.

Impacts on ship navigation coming from Baltic Sea waters are presented in *Table 1*.

As it was mentioned, the idea is to link climate factors and disturbances generated creating the number of hazards in different working environments, taking account different operational modes.

There were specified seven climate hazard categories, listed in *Table 2*, that are also particularly specified in [2]. Additionally three working environment were proposed. Vessels navigating may operate in three working environments presented below:

– harbour – this cover a harbours geographical and administrative area including inner and outer ports, road steadies and anchoring places
– sheltered waters – this includes shielded, near shore and protected water including gulfs, bays, lagoons and straits but also harbour approaches, areas covered by VTS systems etc. This also may include places of refuge.
– open sea – whole remaining part of the sea.

Table 1. Tidal Streams and Currents with the potential to impose a Navigational Constraint

Vessel types (length [feet]/gross tonnage [·1000t]/beam [feet]/draught [feet])	Significant tidal stream or local current speed (along/across) [knots]
ocean-going tanker, ore and bulk carrier 1000+/80-300/140-200/54-80)	3/2
ocean-going tanker, ore and bulk carrier (800-1000/30-100/95-175/26-64)	3/2
tanker, ore and bulk carrier, general cargo (630-800/10-60/60-140/20-54)	7/3
tanker, ore and bulk carrier, general cargo (550-630/8-30/55-105/20-42)	7/3
tanker, ore and bulk carrier, general cargo (300-550/2,5-20/43-105/16-38	7/3
car ferry (300-600/2,5-13/56-90/13-20)	7/3
car ferry (200-300/1-1,5/12-70/2-9)	6/4
tanker, bulk freighter, self unloader, fish factory (200-300/2-3,5/23-65/9-20)	7/3
small tanker, general cargo, fishing: long liner (200-250/2-3/40-60/8-20)	6/3
small tanker, general cargo, fishing: long liner (150-200/1,5-2,5/30-50/6-15)	6/2
small tanker, general cargo, fishing: dragger, long liner (90-150/0,2-0,8/12-50/4-15)	4/2
tugs, small draggers, long liners, pleasure crafts (65-100/0,04-0,25/13-28/5-15	4/2
tugs, work boats, small draggers, inshore long liners, pleasure craft (45-65/0,02-0,16/9-16/4-15)	4/2
tugs, work boats, pleasure craft, fishing: cape islanders, trollers (32-45/0,008-0,05/4-14/3-9)	4/3
tugs, work Boats, fishing trollers, pleasure craft (25-35/0,004-0,02/4-11/3-5	5/4
tugs, work boats, inshore fishing, pleasure craft (12-25/0,001-0,007/3-8/2-4)	5/5

The relationships between the climate factors and hazards affecting navigation are presented in the *Table 2*.

Table 2. Impacts of climate-weather factors on ship navigations

Climate factor	Brief disturbance description		
	Harbour	Sheltered waters	Open sea
extreme summer heat events	all hazards	all, but less extensive	up to tolerable level
extreme precipitation events	reduced visibility, hazards to handling operations, risk of personnel injury	up to tolerable level, reduced visibility, risk of personnel injury	reduced visibility, risk of personnel injury
extreme storm events	all hazards	all hazards, anchor malfunction, heavy seas / high waves effect	all navigation al hazards, reduced speed, higher fuel consumption
winter cold, extreme snowfalls	all hazards	risk of trapped vessel	high risk of trapped vessel
changes of sea, inland water levels	all hazards	up to acceptable level	up to acceptable level
abnormal weather conditions	hazards to harbour infrastructure, power and water supply	up to tolerable level	up to acceptable level
others (fog, extreme low cloud ceiling, volcanic ashes)	hazards to handling and navigation, risk of personnel injury	high risk of accident	high risk of accident

4. Kinds of ships operating at the Baltic Sea waters and their operational modes

The types of ships operating at Baltic sea waters and their modes are:

- high speed craft HSCs (high speed ferries, other high speed recreational and commercial craft),
- fishing vessels (fish processing and vessels of various types and operations),
- recreational vessels (sailing dinghies and yachts, motor boats, small personal watercraft, rowing boats, sports fishing, windsurfer, kite boards, tall ships, recreational submarines and dive support craft),
- anchored vessels,
- other operational vessels (barges, dredgers, dry cargo barge, offshore production and support, salvage, tank barges, tugs and tows),
- military vessels (surface warships, submarines, royal fleet auxiliaries),
- other vessels (seaplanes, wing-in-ground craft – WIG, hovercraft).

Apart from those classifications mentioned above there are several modes of operation. Detailed list of operational modes is presented in table below.

From the other point of view VTS systems based on AIS or/and radar identification use the following navigational status of ships: not defined, reserved, under way sailing, engaged in fishing, aground, moored, constrained by her draught, restricted manoeuvrability, not under command, at anchor.

To supplement information given by the vessel traffic servicing systems this should be mentioned that these systems take the following information about the ship type: reserved for future use, not available, other type, non-combatant ship, medical transport, law enforcement, anti-pollution equipment, port tender, tug, SAR, pilot vessel, high speed craft, pleasure craft, sailing, military operations, diving operations, dredging or underwater operations, towing (length >200 m or width > 25 m), towing, fishing, wing in ground, cargo, passenger, tanker.

5. Passenger traffic across the Baltic Sea

Main routes for passenger ferries (maritime ferries) traffic across the Baltic Sea are traditionally following links (Map BA16a): Denmark – Germany, Denmark – Sweden, Finland – Åland, Finland–Sweden, Finland – Estonia. These major ferry routes are used by about 40 million passengers annually [23]. All in all about 134,000 passengers travelled by ship in the European member states around the Baltic Sea in 2009 (Denmark and Germany including North Sea) [12]. The development of passenger transport by ferries has been manly stable to positive during the recent years. However, ferries in the BSR carry not only passengers but are in many cases carriers mainly for trucks, trailers and partly railway wagons. As such they also play an important role in cargo transport across the Baltic Sea.

The next two sections of this chapter are devoted to analysis of the operation process and the climate-weather process influence on this operation of an exemplary maritime ferry operating between the

Gdynia Port in Poland and the Karlskrona Port in Sweden.

5.1. Operation process of maritime ferry operating at the Baltic Sea waters between Gdynia Port and Karlskrona Port

The considered maritime ferry is a passenger Ro-Ro ship operating at the Baltic Sea between Gdynia and Karlskrona ports on regular everyday line. Its route is illustrated in *Figure 1*.

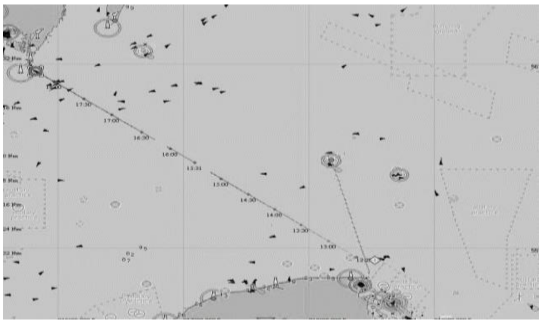

Figure 1. Maritime ferry route between Gdynia and Karlskrona ports

The ferry is composed of a number of main subsystems having an essential influence on its safety. These subsystems are illustrated in *Figure 2* and *Figure 3*. The scheme of the ferry technical system is presented in *Figure 3* where there are distinguished its following subsystems:

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.

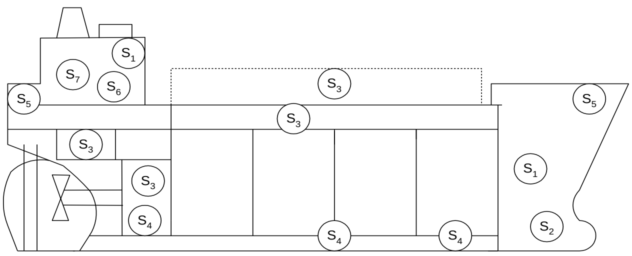

Figure 2. Subsystems having an essential influence on the ferry safety

In the safety analysis of the ferry, we omit the protection and rescue subsystem S_6 and the social subsystem S_7 and we consider its strictly technical subsystems S_1, S_2, S_3, S_4 and S_5 only, further called the ferry technical system.

The navigational subsystem S_1 is composed of one general component $E_{11}^{(1)}$, 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 $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$;
– the subsystem S_{22} which consist of 3 thrusters $E_{21}^{(2)}$, $E_{22}^{(2)}$, $E_{31}^{(2)}$;
– the subsystem S_{23} which consist of twin pitch propellers $E_{41}^{(2)}$, $E_{51}^{(2)}$;
– the subsystem S_{24} which consist of twin directional rudders $E_{61}^{(2)}$, $E_{71}^{(2)}$.

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 $E_{11}^{(3)}$, $E_{21}^{(3)}$;
– the subsystem S_{32} which consist of 1 remote fore car deck to main deck $E_{31}^{(3)}$;
– the subsystem S_{33} which consist of passenger gangway to Gdynia Terminal $E_{41}^{(3)}$;
– the subsystem S_{34} which consist of passenger gangway to Karlskrona Terminal $E_{51.}^{(3)}$.

The stability control subsystem S_4 is composed of :

– the subsystem S_{41} which consist of an anti-heeling system $E_{11}^{(4)}$, which is used in port during loading operations;
– the subsystem S_{42} which consist of an anti-heeling system $E_{21}^{(4)}$, 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 $E_{11}^{(5)}$;
– the subsystem S_{52} which consist of fore mooring and anchor winches $E_{21}^{(5)}$;
– the subsystem S_{53} which consist of fore mooring winches $E_{31}^{(5)}$.

The subsystems S_1, S_2, S_3, S_4, S_5, indicated in *Figure 4* are forming a general series safety structure of the ferry technical system presented in *Figure 3*.

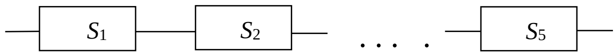

Figure 3. The general scheme of the ferry technical system safety structure

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

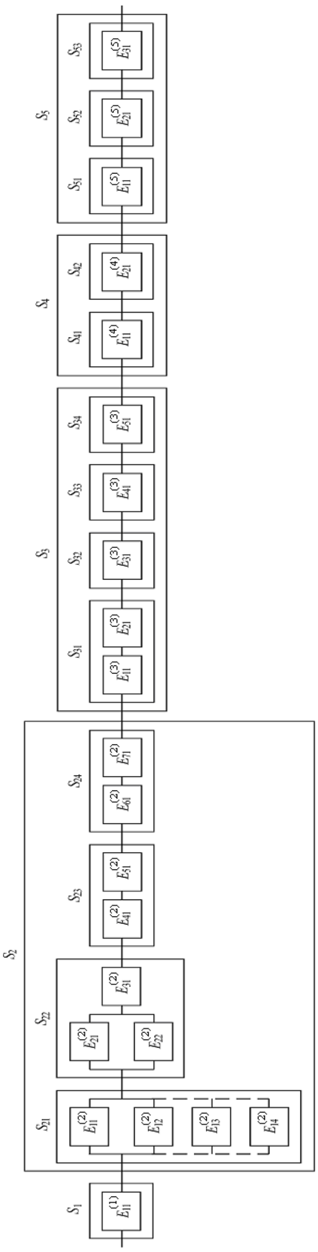

Figure 4. The detailed scheme of the ferry technical system structure

However, the ferry technical system safety structure and its subsystems and components safety depend on its changing in time operation states. For the considered ferry technical system, after discussion with its operators, we distinguish the following as its eighteen operation states:

– an operation state z_1 – loading at Gdynia Port,
– an operation state z_2 – unmooring operations at Gdynia Port,
– an operation state z_3 – leaving Gdynia Port and navigation to “GD” buoy,
– an operation state z_4 – navigation at restricted waters from “GD” buoy to the end of Traffic Separation Scheme,
– an operation state z_5 – navigation at open waters from the end of Traffic Separation Scheme to “Angoring” buoy,
– an operation state z_6 – navigation at restricted waters from “Angoring” buoy to “Verko” Berth at Karlskrona,
– an operation state z_7 – mooring operations at Karlskrona Port,
– an operation state z_8 – unloading at Karlskrona Port,
– an operation state z_9 – loading at Karlskrona Port,
– an operation state z_{10} – unmooring operations at Karlskrona Port,
– an operation state z_{11} – ferry turning at Karlskrona Port,
– an operation state z_{12} – leaving Karlskrona Port and navigation at restricted waters to “Angoring” buoy,
– an operation state z_{13} – navigation at open waters from “Angoring” buoy to the entering Traffic Separation Scheme,
– an operation state z_{14} – navigation at restricted waters from the entering Traffic Separation Scheme to “GD” buoy,
– an operation state z_{15} – navigation from “GD” buoy to turning area,
– an operation state z_{16} – ferry turning at Gdynia Port,
– an operation state z_{17} – mooring operations at Gdynia Port,
– an operation state z_{18} – unloading at Gdynia Port.

The influence of the above defined operation states changing on the changes of the ferry technical system safety structure is as follows.

At the operation states z_1 and z_{18}, the ferry technical system is composed of two subsystems S_3 and S_4 forming a series structure shown in *Figure 5*.

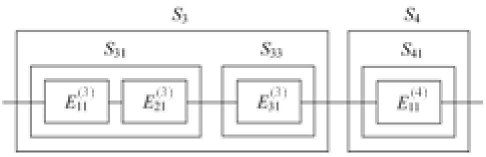

Figure 5. The scheme of the ferry technical system structure at the operation states z_1 and z_{18}

At the operation states z_2, z_7, z_{10} and z_{17}, the ferry technical system is composed of three subsystems S_1, S_2 and S_5 forming a series structure shown in *Figure 6*.

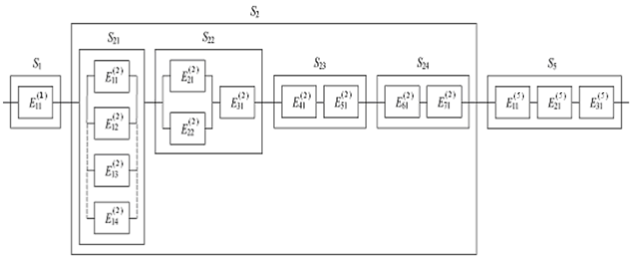

Figure 6. The scheme of the ferry technical system structure at the operation states z_2, z_7, z_{10} and z_{17}

At the operation states z_3, z_{11}, z_{15} and z_{16}, the ferry technical system is composed of two subsystems S_1 and S_2 forming a series structure shown in *Figure 7*.

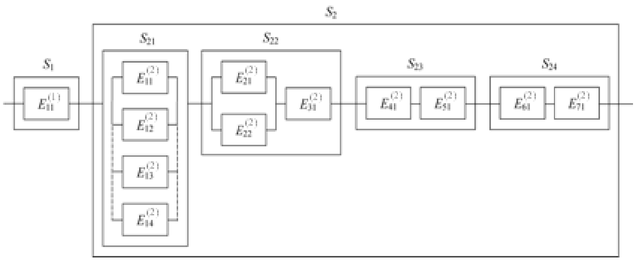

Figure 7. The scheme of the ferry technical system structure at the operation z_3, z_{11}, z_{15} and z_{16}

At the operation states z_4, z_5, z_{12}, z_{13} and z_{14}, the ferry technical system is composed of three subsystems S_1, S_2 and S_4 forming a series structure shown in *Figure 8*.

At the operation state z_6, the ferry technical system is composed of three subsystems S_1, S_2 and S_4 forming a series structure shown in *Figure 9*.

At the operation state z_8 and z_9, the ferry technical system is composed of two subsystems S_3 and S_4 forming a series structure shown in *Figure 10*.

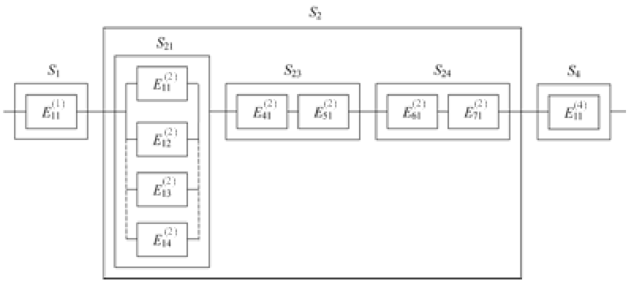

Figure 8. The scheme of the ferry technical system structure at the operation states z_4, z_5, z_{12}, z_{13} and z_{14}

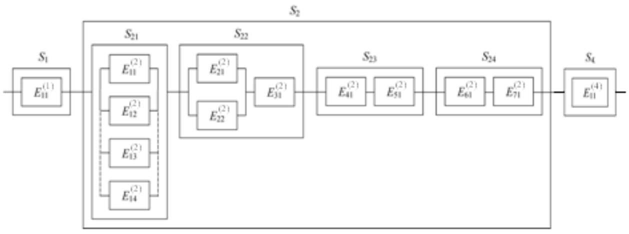

Figure 9. The scheme of the ferry technical system structure at the operation state z_6

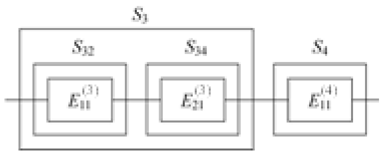

Figure 10. The scheme of the ferry technical system structure at the operation states z_8 and z_9

The modelling of the maritime ferry operation process is done in [4] and next its unknown parameters statistical identification is performed in [8].

5.2. Climate-weather impact on operation process of maritime ferry operating at the Baltic Sea waters between Gdynia Port and Karlskrona Port

Apart from the influence of the considered maritime ferry operation process, the climate-weather changes in its operating environment also have an essential influence on its safety structure and its subsystems and components safety. The different kinds of those impacts are discussed in details in [3].

Considering different environmental conditions of the maritime ferry technical system dependent of its operating area (*Figure 1*), the climate-weather hazards and their consequences in the following three cases should be analyzed:

– Maritime Ferry operating at Gdynia Port and Karlskrona Port waters;

- Maritime Ferry operating at the Baltic Sea restricted waters in Gdynia bay and Karlskrona bay;
- Maritime Ferry operating at the Baltic Sea open waters between Gdynia bay and Karlskrona bay.

To identify those different kinds of the climate-weather impacts on the considered maritime ferry technical system operation and safety, firstly the modelling of the climate-weather change process in the ferry operating area is done in [5] and next its unknown parameters statistical identification is performed in [9]. In these reports, the following four cases of the climate-weather operation conditions are distinguished:

- Climate-Weather Change Process for Maritime Ferry operating at Gdynia Port Area;
- Climate-Weather Change Process for Maritime Ferry operating at the Baltic Sea Restricted Waters;
- Climate-Weather Change Process for Maritime Ferry operating at the Baltic Sea Open Waters;
- Climate-Weather Change Process for Maritime Ferry operating at Karsklone Port Area.

5. Conclusion

The results of the reports [5] and [9] will be further developed and used in the next GMU reports of the project.

Modelling Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET) performed in [4] and Modelling Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH) performed in [5] will be join in [6] to construct the Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH). Similarly, Identification methods and procedures of Critical Infrastructure Operation Process (CIOP) including Operating Environment Threats (OET), presented in [8] and identification methods and procedures of Climate-Weather Change Process (C-WCP) including Extreme Weather Hazards (EWH) presented in [9] will be collected together in [10] to create the identification methods and procedures of unknown parameters of Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH).

Practical applications of the results of the above reports will be done in [7] to modelling the maritime ferry transportation system operation process at the Baltic Sea area using the Critical Infrastructure Operation Process General Model (CIOPGM) related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) in this region and in [11] to evaluation of unknown parameters of the maritime ferry transportation system operation process related to Operating Environment Threats (OET) and Extreme Weather Hazards (EWH) at the Baltic Sea area.

Further, the identified operation process of the maritime ferry will be used in the reports prepared in the next steps of the research described in [19].

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