Bogalecka Magda

Kołowrocki Krzysztof

Soszyńska-Budny Joanna
Maritime University, Gdynia, Poland

Ledóchowski Marek
Maritime Office, Gdynia, Poland

Reszko Marek
Maritime Search and Rescue Service, Gdynia, Poland

Methodology for shipping critical infrastructure network safety and resilience to climate change analysis

Keywords

critical infrastructure (CI), shipping, Baltic Shipping Critical Infrastructure Network (BSCIN), climate/weather impact, resilience, taxonomy

Abstract
The shipping as a critical infrastructure is presented in the paper. The selected basic notions concerned with shipping critical infrastructure as well as extreme weather events and climate change impacts on its safety and resilience are given. Next, these notions and terminology specific for Baltic Shipping Critical Infrastructure Network (BSCIN) are indicated and described in the paper.

1. Introduction

The European Commission described the *critical infrastructure* (CI) as an asset or system which is essential for the maintenance of vital societal functions. The damage to a critical infrastructure, its destruction or disruption by natural disasters, terrorism, criminal activity or malicious behaviour, may have a significant negative impact for the security of the EU and the well-being of its citizens.
There are two main sectors of European Critical Infrastructures (ECI) that are divided into some subsectors [9].
Sector I – energy:
1) electricity (infrastructures and facilities for generation and transmission of electricity in respect of supply electricity),
2) oil (oil production, refining, treatment, storage and transmission by pipelines),
3) gas (gas production, refining, treatment, storage and transmission by pipelines, LNG terminal).
Sector II – transport:
1) road transport,
2) rail transport,
3) air transport,
4) inland waterways transport,
5) ocean and short-sea shipping and ports.
Transportation infrastructure is defined as physical distribution systems critical to supporting the national security and economic well-being of this nation, including the national airspace systems, airlines, and aircraft, and airports; roads and highways, trucking and personal vehicles; ports and waterways and the vessels operating thereon; mass transit, both rail and bus; pipelines, including natural gas, petroleum, and other hazardous materials; freight and long haul passenger rail; and delivery services [28], [35].
Dependency of critical infrastructures is defined as a linkage or connection between two infrastructures, through which the state of one infrastructure influences or is correlated to the state of the other [29]. This occurrence is defined as the *CI network cascading effect* that means degrading effects occurring within an infrastructure and between infrastructures in their operating environment,

including situations in which one infrastructure causes degradation of another ones, which again causes additional degradation in other infrastructures and in their operating environment.The shipping subsector is a critical infrastructure network which collides with other sectors, for example with wind energy sector. Wind farms occupy more and more areas and there is usually safety zone of 500 meters around wind farms, with restrictions for shipping, and a buffer zone of 500 meters around the cables, which prohibits anchoring of vessels [19].

The main environmental effects of shipping and other activities at sea include air pollution, illegal deliberate and accidental discharges of oil, hazardous substances and other wastes, and the unintentional introduction of invasive alien organisms via ships' ballast water or hulls. Shipping adds to the problem of eutrophication of the Baltic Sea with its nutrient inputs from sewage discharges and nitrogen oxides (NO_x) emissions [22]. In our opinion, those facts are sufficient and reasonable to consider the set of operating in the Baltic Sea area as a shipping critical infrastructure network what currently is not clearly acceptable in critical infrastructure safety analysis. Our suggestion is to accept our approach without any objections [2].

The set of ships operating at the Baltic Sea waters at the fixed moment of time (or at the fixed time interval) we called the Baltic Shipping Critical Infrastructure Network (BSCIN) that is particular described in [6].

To ensure compatibility in the usage and communication of key terms across the work packages of EU-CIRCLE project the common "working terminology" should be fixed at the first steps of the project activity.

2. State of art

Before the considerations on taxonomy of shipping critical infrastructure at the Baltic Sea region, we refer to definitions of selected basic notions concerned with shipping critical infrastructures as well as climate and weather impacts on their safety included in the report [12].

2.1. Shipping CI terminology – general terms

Maritime transport by definition means shipment of goods (cargo) and people by sea and other waterways.

Waterways are defined as navigable waterways capable of carrying marine traffic [33]. Port operations are a necessary tool to enable maritime trade between trading partners. To ensure smooth port operations and to avoid congestion in the harbour it is inevitable to permanently upgrade the ports physical infrastructure, invest in human capital, fostering connectivity of the port and upgrade the port operations to prevailing standards. Hence, *port operations* can be defined as all policies, reforms and regulations that influence the infrastructure and operations of *port facilities* including *shipping* services [32]. Therefore ports take an essential feature in the shipping process.

Port means a facilitie designed to dock, load, and unload marine vesseles [33]. Also, *port* term is used the agency (port authority), which administers use of public wharves and port properties [1].

Different types of vessel are used in the shipping. The common *vessel types* [23], [33] are as follows:

– *container ship* is a vessel specially designed to transport containerized cargo,
– *dry bulk cargo ship* is a vessel specially designed to transport dry bulk cargo (e.g. ore, grain),
– *general cargo ship* includes general cargo, tween-deck, multipurpose, heavy lift, and other vessels,
– *gas carrier ship* is a vessel specially designed to transport gases,
– *passenger ferrie* is a vessel specially designed to carry passengers,
– *roll on / roll of ship (ro/ro ship)* is a vessel specially designed to transport vehicles and to load and unload them under their own power,
– *supply boat* means offshore supply, inshore workboat, police/fire service boat,
– *tank ship* is a vessel specially designed to transport liquid cargo,
– *tug and towboat* means harbour tugs, line-haul towboats, offshore tugs.

The State whose flag each ship is entitled to fly is called the *flag state* [16]-[17].

The shipping process can be disturbed by ship accidents or incidents. The weather impacts may be a reason of an accident as well as the scale of an accident and its consequences may be intensified by the weather impacts.

The United States Department of Homeland Security defines *the transportation security incident* as a security incident resulting in a significant loss of life, environmental damage, transportation system disruption, or economic disruption in a particular area [33].

European Maritime Safety Agency defines *casualty event* and *maritime incident* as follows. *Casualty event* means unwanted event in which there was some kind of energy release with impact on people and/or ship including its equipment and its cargo or environment [16]-[17], while the *marine incident* is an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operations of a ship that endangered, or, if not corrected, would endanger the safety of the ship,

its occupants or any other person or the environment [16]-[17]. Moreover, EMSA defines a *marine casualty* as an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship: 1) the death of, or serious injury to, a person, 2) the loss of a person from a ship, 3) the loss, presumed loss or abandonment of a ship, 4) *material damage* to a ship (is a damage that significantly affects the structural integrity, performance or operational characteristics of marine infrastructure or a ship, and requires major repair or replacement of a major component or components; or destruction of the marine infrastructure or ship), 5) the stranding or disabling of a ship, or the involvement of a ship in a collision, 6) material damage to marine infrastructure external to a ship, that could, seriously endanger the safety of the ship, another ship or an individual or 7) severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a ship or ships [16]-[17].

On the other hand, according to the International Maritime Organization (IMO), ship accidents are classified as 1) very serious, 2) serious, 3) less serious and 4) marine incidents [23]. *Very serious accidents* are casualties to ships which involve total loss of the ship, loss of life, or *severe pollution* (severe pollution means pollution which, as evaluated by the coastal State(s) affected or the flag Administration, as appropriate, produces a major deleterious effect upon the environment, or which would have produced such an effect without preventive). *Serious accidents* are casualties to ships which do not qualify as very serious casualties and which involve a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect, etc., resulting in: immobilization of main engines, extensive accommodation damage, severe structural damage, such as penetration of the hull under water, etc., rendering the ship unfit to proceed, or pollution (regardless of quantity), and/or a breakdown necessitating towage or shore assistance. *Less serious accidents* are casualties to ships which do not qualify as very serious casualties or serious casualties and for the purpose of recording useful information also include marine incidents. Which themselves include hazardous incidents and near misses.

Moreover, IMO and EMSA point events that initial sea accidents such as follows.

– *Collision* means a casualty caused by ships striking or being struck by another ship, regardless of whether the ships are underway, anchored or moored. This type of casualty event does not include ships striking underwater wrecks. The collision can be with other ship or with multiple ships or ship not underway.
– *Contact* is a casualty caused by ships striking or being struck by an external object. The objects can be: floating object (cargo, ice, other or unknown), or fixed object, but not the sea bottom, or flying object.
– *Grounding/stranding* means a moving navigating ship, either under command, under power, or not under command, drifting, striking the sea bottom, shore or underwater wrecks.
– *Fire/explosion* is an uncontrolled ignition of flammable chemicals and other materials on board of a ship (fire is the uncontrolled process of combustion characterised by heat or smoke or flame or any combination of these, explosion is an uncontrolled release of energy which causes a pressure discontinuity or blast wave).
– *Damage to equipment* is a damage to equipment, system or the ship not covered by any of the other casualty type. Loss of function may also be the result of operating outside the specified performance criteria (e.g. overload, overcapacity) [16]-[17].
– *Capsizing/listing* is a casualty where the ship no longer floats in the right-side-up mode due to: negative initial stability (negative metacentric height), or transversal shift of the centre of gravity, or the impact of external forces (capsizing when the ship is tipped over until disabled; listing when the ship has a permanent heel or angle of loll).
– *Hull failure* means a failure affecting the general structural strength of the ship.
– *Loss of control* means a total or temporary loss of the ability to operate or manoeuvre the ship, failure of electric power, or to contain on board cargo or other substances: loss of electrical power is the loss of the electrical supply to the ship or facility (loss of propulsion power is the loss of propulsion because of machinery failure; loss of directional control is the loss of the ability to steer the ship; loss of containment is an accidental spill or damage or loss of cargo or other substances carried on board a ship).
– *Missing* is a casualty to a ship whose fate is undetermined with no information having being received on the loss and whereabouts after a reasonable period of time.
– *Flooding/foundering*. A casualty event when the ship is taking water on board (foundering will be considered when the vessel has sunk; foundering should only be regarded as the first casualty event if we do not know the details of the flooding which caused the vessel to founder, in the chain of events foundering can be the last casualty event in this case there is the need to add accidental events;

flooding refers to a casualty when a vessel takes water on board and can be: progressive if the water flow is gradual, massive if the water flow is extensive).

2.2. Climate change terminology

Climate change means a large-scale, persistent (long-term) and systematic changes in the typical weather patterns, but it is different from climate variability which is associated with short-term fluctuations in climate [8]. In other words, according to the Inter-governmental Panel on Climate Change (IPCC) *climate change* is defined as a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use [24]. Opposite to it the e*xtreme weather event* means an event that is rare at a particular place and time of year. Definitions of rare vary, but an *extreme weather event* would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called *extreme weather* may vary from place to place in an absolute sense. *Single extreme events* cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of *extreme weather* persists for some time, such as a season, it may be classed as an *extreme climate event*, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season) [15], [24]. *Hydro-meteorological hazard* is the process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage [36]. *Hydro-meteorological hazards* include tropical cyclones (also known as typhoons and hurricanes), thunderstorms, hailstorms, tornados, blizzards, heavy snowfall, avalanches, coastal storm surges, floods including flash floods, drought, heat waves and cold spells. Hydro-meteorological conditions also can be a factor in other hazards such as landslides, wild land fires, locust plagues, epidemics, and in the transport and dispersal of toxic substances and volcanic eruption material [36].

Maritime transport sector seems to be one specially affected by the climate change. There are climate pressure and risk coming from them [18]:

– sea level rise – navigability could be affected by changes in sedimentation rates and location of shoals,
– change in sea conditions – more severe storms and extreme waves might affect ships and increase number of accidents,
– less days below freezing – reduce problems with ice accumulation on vessels, decks, riggings and docks; occurrence of dangerous ice fog,
– reduced sea ice – improved access, longer shipping seasons, new shipping routes.

Because shipping operation process closely depends on the port infrastructures, the climate-weather impacts on the port infrastructures such as extreme storm events, sea level rise and floods or landslide should be also considered. These weather impacts may cause both devastation of port infrastructure and interruptions and bottlenecks in the flow of products through ports [4].

2.3. Resilience terminology

Resilience according to the critical infrastructure is defined as an ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions [26]. Then, resilience procedures increase the *critical infrastructure secure* that is defined as reducing the risk to critical infrastructure by physical means or defensive cyber measures to intrusions, attacks, or the effects of natural or manmade disasters [33]. Based on it the *marine safety investigation* means an investigation or inquiry into a marine casualty or marine incident, conducted with the objective of preventing marine casualties and marine incidents in the future. The investigation includes the collection and analysis of evidence, the identification of causal factors and the making of safety recommendations as necessary [16]-[17]. For each critical infrastructure the *safety plan from owner/manager of critical infrastructure* should be prepared. The document indicates a plan that ensures confidentiality, integrity and availability of the organizational, human, material, information-communication and other solutions, as well as permanent and graded security measures necessary for the continuous functioning of critical infrastructure [10]. Therefore the *emergency search and rescue facilities* (facilities equipped to respond to maritime emergencies) are required [33].

The CI resilience procedures are necessary because of some critical infrastructure features make them easily influenced by some external factors and hazards coming from its operating environment

dangerous changes forced by natural disaster impacts. From this poin of view we defined the CI *vulnerability* (in the climate change context) as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity [25].
Moreover, the mitigation concept is closely related to the resilience. The IPCC defines the *mitigation* of disaster risk and disaster as the lessening of the potential adverse impacts of physical threats, including those that are human-induced, and natural hazards through actions that reduce hazard, exposure, and vulnerability [24].

3. Shipping critical infrastructure networks at the Baltic Sea region taxonomy

The critical infrastructure network is a set of interconnected and interdependent critical infrastructures interacting directly and indirectly at various levels of their complexity and operating activity. Critical infrastructures in mutually dependant relationships between themselves interacting at various levels of their complexity is defined as the *critical infrastructure interdependence* while critical infrastructures in mutually direct and indirect connections between themselves is defined as *critical infrastructure interconnections*.
Considering definitions of main notions from the above methodology concerned with critical infrastructures and their networks, the nature and features of the industrial installations at the Baltic Sea region, and based on the *identification of the Baltic Sea critical infrastructures* (that means the procedure based on specified local criteria leading to designate system belonging to Baltic Sea infrastructure network as a critical infrastructure system), we are convinced to distinguish the following 8 main critical infrastructure networks operating in this region:
– port critical infrastructure network,
– shipping critical infrastructure network,
– oil rig critical infrastructure network,
– wind farm critical infrastructure network,
– electric cable critical infrastructure network,
– gas pipeline critical infrastructure network,
– oil pipeline critical infrastructure network,
– ship traffic and operation information critical infrastructure network.

We classify the above distinguished shipping critical infrastructure network to the class of so called dynamic installations and the remaining distinguished 7 critical infrastructures to the class of so called static installations [2].
We suppose that 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 [13]. Thus, each ship takes important part in shipping operation process.

3.1. Critical infrastructure taxonomy

We defined the *Baltic Sea infrastructure* as an industry and other system (e.g. drilling platforms, gas and oil pipelines, wind farms, telecommunication systems, waterways, *maritime transport*, ports with their intermodal connections), performing activities within the Baltic sea area. The *Baltic Sea infrastructure* belongs to *European infrastructure* that is defined as the network of interconnected and interdependent infrastructures located in EU member states that function collaboratively in order to ensure a continuous production flow of essentials, goods and services. Moreover, we defined the *Baltic Sea critical infrastructure* as complex system located and operating within the Baltic Sea and ashore that significant features are inside-system dependencies and outside-system dependencies, that in the case of its degradation have significant destructive influence on the health, safety and security, economics and social conditions of large human communities and territory areas. Next, the structure and flow of the inner, outer and cross dependencies of the Baltic Sea infrastructures is defined by the *Baltic Sea infrastructure network*.
The BSCIN is closely cooperating and interacting with the Baltic port critical infrastructure (BPCIN) defined in [5]. The BSCIN also closely cooperates and interacts with the Baltic ship traffic and port operation information critical infrastructure (BSTPOICIN) that is described in [21].
More general terms referred to the CI networks at the Baltic Sea region taxonomy are given in [3].

3.2. Climate change taxonomy

The BSCIN interacts strongly with the climate-weather change process [14], what will be discussed in details in the next reports of the project [27]. The *climate-weather change process* is the process of the climate-weather states changing considered in time for a fixed area. Moreover, we defined the *Baltic Sea climate change* as any changes in climate within the Baltic Sea area over time either due to natural variability or as a result of human activity, while the *extreme weather event* means the meteorological conditions that are dangerous and happen at a

particular place and time and can generate severe hazards.

Seismic events, tsunamis, rough sea with strong swells, winds, and storms could directly affect a shipping operation process. The seismic events and tsunamis are unlikely in the Baltic Sea region than they can be omitted in this Section. Next, according to the BSCIN and corresponding to climate hazards impacts mentioned in Section 2.2, the following extreme weather events should be considered.

Extreme cold effects can vary across different areas of the country. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered *extreme cold*. Whenever temperatures drop decidedly below normal and as wind speed increases, heat can leave your body more rapidly. These weather-related conditions may lead to serious health problems. Extreme cold is a dangerous situation that can bring on health emergencies in susceptible people, such as those without shelter or who are stranded, or who live in a home that is poorly insulated or without heat [31]. Low temperature during precipitation can cause icing of ship's construction.

Extreme heat means conditions are defined as summertime temperatures that are substantially hotter and/or more humid than average for location at that time of year. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a "dome" of high atmospheric pressure traps hazy, damp air near the ground. Extremely dry and hot conditions can provoke dust storms and low visibility. Droughts occur when a long period passes without substantial rainfall. A heat wave combined with a drought is a very dangerous situation [31]. An *extreme heat event* is also referred to as a *heat wave*. Too high air temperature can cause minor problems with cooling of various ship's systems. *Thermal expansion* has influence on the sea level. This refers to the increase in volume (and decrease in density) that results from warming water. A warming of the ocean leads to an expansion of the ocean volume and hence an increase in sea level [24].

Sea-level rise is an increase in the mean level of the sea. Eustatic sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean. Relative sea-level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence. In areas subject to rapid land-level uplift, relative sea level can fall [25]. *Extreme coastal high water* (also referred to as *extreme sea level*) depends on average sea level and regional weather systems. Extreme coastal high water events are usually defined in terms of the higher percentiles (e.g., 90th to 99.9th) of a distribution of hourly values of observed sea level at a station for a given reference period [24], [26]. *Significant wave height* is defined as the average height of the highest one-third of the wave heights (trough to peak) from sea and swell occurring in a particular time period. The two types of sea level data: *Relative* and *absolute sea level trends* complement each other, and each is useful for different purposes. *Relative sea level trends* show how sea level change and vertical land movement together are likely to affect coastal lands and infrastructure, while *absolute sea level trends* provide a more comprehensive picture of the volume of water in the world's oceans, how the volume of water is changing, and how these changes relate to other observed or predicted changes in global systems (e.g., increasing ocean heat content and melting polar ice caps) [34].

Too high or too low water level can cause problems during loading and discharging operations by ramps and passenger's gangway. Lack of minimum under keel clearance could be a reason to cease voyage in order to avoid danger of grounding.

Extreme precipitation expresses large precipitation amounts or intensities, or long-duration dry spells. Even though droughts can be considered as extreme precipitation events, we address here mainly events of increased precipitation intensity. By definition, it rarely occurs in the prevalent climate. The potential damaging effects are implied by the rare occurrence as neither nature nor society are prepared for the conditions. Usually one relates the degree of extremeness to the expected return period of incidents estimated from regular observations [8].

Extreme wind is the wind which is strong enough to be dangerous for people, or cause significant damage to buildings and property, usually faster than 100 km/h (>118 km/h = 12 Beaufort scale, hurricane). *Gust* is a rapid increase in the strength of the wind relative to the mean strength at the time [30].

Extreme wind can cause:

- destruction of buildings, including roofing being blown off, broken windows, and other flying debris,
- large scale forest damage and fallen trees or branches falling onto power-lines,
- high-sided vehicles and outdoor equipment being blown over,
- very tall buildings, suspension bridges and transmission lines can suffer structural failures.

Winds over 15 m/s from the ship's side cause drifting and list (heel) due to large wind exposed area. Additionally, raise the risk of collision with other ships, berthing difficulties and very unlikely contact with offshore installations exist.

Fog means the extremely low visibility that has major impacts on transport [11]. Fog causes risk of collision with other ships or contact with port facilities and other external objects.
Intense rain(fall) also called as *heavy rain(fall)* means a rain characterized by a rainfall rate greater than or equal to 50 mm/h. Very heavy rainfall or snowfall with squalls can cause risk of drifting, collision with other ships and contact with external objects
Rainfall intensity defined the rain rate of fall. *Very light* means that the scattered drops do not completely wet a surface. *Light* means it is greater than a trace and up to 2.5 mm an hour. *Moderate* means the rate of fall is between 2.6 mm to 7.5 mm per hour. *Heavy* means 7 mm per hour or more [20].
Hail means solid precipitation in the form of balls or pieces of ice (hailstones) with diameters ranging from 5 to 50 mm or even more [30].
Storms mean 1) an atmospheric disturbance involving perturbations of the prevailing pressure and wind fields, on scales ranging from tornadoes (1 km across) to extratropical cyclones (2000-3000 km across) or 2) wind with a speed between 48 and 55 knots (Beaufort scale wind force 10) [37].
More general terms referred to the climate change impacts on CI networks at the Baltic Sea region taxonomy are given in [3]. Additionally, the climate-weather hazard impacts and consequences maritime ferry operating at Gdynia Port and Karlskrone Port waters, the Baltic Sea restricted waters in Gdynia bay and Karlskrone bay as well as the Baltic Sea open waters between Gdynia bay and Karlskrone bay are given in detail in [14].

3.3. Resilience taxonomy appropriate for shipping CI networks at the Baltic Sea

Critical infrastructure resilience to climate change is defined as the capacity of critical infrastructure to be able to absorb and to recover from hazardous events appearing as a result of climate change. Efforts, like policies, procedures and actions, taken to prolong the proper and effective functioning of a critical infrastructure and providing its essential services when it is exposed to menaces we called as *strengthening critical infrastructure resilience*, while *strengthening critical infrastructure resilience to climate change* means increasing CI capacity through its components and subsystems parameters improving and its operating environment parameters modification to achieve its characteristics stronger what allow its functioning in its operating environment to be able to absorb and to recover from hazardous events appearing as a result of climate change.
Resilience strengthening strategy to climate-weather hazards for BSCIN we consider as *response* or *redundancy* that are defined in the climate change context as follows.
Response – the reaction (policies and action) during or immediately after a disaster in order to reduce its impacts, to ensure the functioning of basic systems (infrastructures) and to prevent transitions of the system or infrastructure into a crisis situation. It usually includes activities that address the short-term, direct effects of an incident. The response includes immediate actions to save lives, protect property, and meet basic human needs [31].
Redundancy – properties of a critical infrastructure that allow for use alternate options, choices, and substitutions under stress, in order to satisfy functional requirements in threat situations of disruption, degradation, or loss of functionality coming from climate change. In other words, *redundancy* means the speed with which disruptions coming from climate change can be overcome, in order to contain losses and avoid future disruption, and with which safety, functionality and stability of critical infrastructure can be restored.
There are examples of *response* procedures used in the resilience strengthening strategy to climate-weather hazards for BSCIN:
– using of the ballast and anti-heeling systems in order to reduce influence of high or low water level in port,
– assistance of tugs during manoeuvres in the case of strong wind,
– reducing of speed in the case of extreme precipitation, fog or sailing in ice-condition.

The idea of *port of refuge* is also an example of response operation. *Port of refuge* means a port, not on a ship's itinerary, which the ship calls at due to some unforeseen hazard at sea and where the ship may undergo repairs, refuel, or rescue cargo [7].
There are examples of *redundancy* procedures used in the resilience strengthening strategy to climate-weather hazards for BSCIN:
– vessel has to proceed with safe speed and extreme caution in the case of decries of sea level,
– during strong winds vessel has to adjust heading to keep her inside the limits of fairway,
– recommendation of speed reduction in the case of extreme precipitation, fog or sailing in ice-condition.

The particular description of resilience strengthening strategy to climate-weather hazards for maritime ferry operating at Gdynia Port and Karlskrone Port waters, the Baltic Sea restricted waters in Gdynia bay and Karlskrone bay as well as the Baltic Sea open waters between Gdynia bay and Karlskrone bay are given in [14].

4. Conclusion

The Baltic Shipping Critical Infrastructure Network (BSCIN) is particularly described in [6]. The BSCIN is an element of the Global Baltic Network of Critical Infrastructure Networks (GBNCIN). The presented in this paper terminology and methodology with regard to the weather change and its impact on BSCIN as well as BSCIN resilience and resilience strengthening to climate are used in the EU-CIRCLE project entitled "A pan – European framework for strengthening Critical Infrastructure resilience to climate change".

Acknowledgments

The paper presents the results developed in the scope of the EU-CIRCLE project titled "A pan – European framework for strengthening Critical Infrastructure resilience to climate change" that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653824. http://www.eu-circle.eu/.

References

[1] American Association of Port Authorities. Glossary of Maritime Terms. [available at: http://www.aapa-ports.org/Industry/content.cfm?ItemNumber=1077; accessed 13.02.2016].

[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] Blokus-Roszkowska, A., Bogalecka, M. & Kołowrocki, K. (2016). Methodology for Baltic Sea region critical infrastructures safety and resilience to climate change analysis. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7 2, 93-103.

[4] Blokus-Roszkowska, A., Guze, S., Kołowrocki, K. et al. (2016). Methodology for Port Critical Infrastructure Network Safety and Resilience to Climate Change Analysis. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7, 2, 139-149.

[5] Blokus-Roszkowska, A., Guze, S., Kołowrocki, K. et al. (2016). Port Critical Infrastructure Network. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7, 2, 15-28.

[6] Bogalecka, M., Kołowrocki, K., Soszyńska-Budny J. et al. (2016). Shipping Critical Infrastructure Network. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7, 1-2, 43-52.

[7] Brodie, P. (2013). *Dictionary of shipping terms*, Informa Law from Routledge.

[8] Climate science glossary. [available at: https://docs.google.com/document/d/1FtoxQwrQXY1a5DNbk7LGOxzc8DvciZjvArLRDFMRY1o/edit?pref=2&pli=1; accessed 13.02. 2016].

[9] Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection. (2008) *Official Journal of the European Union* L 345/75.

[10] Croatian Parliament. (2013). Croatian Law on critical infrastructures. *Official Gazette* 56, 13.

[11] Diaz, H. F. & Murnane, R. J. (2008). *Climate extremes and society*. Cambridge.

[12] EU-CIRCLE Report D1.1 (2015). *EU-CIRCLE Taxonomy*.

[13] 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).*

[14] EU-CIRCLE Report D1.4-GMU4. (2016). *Contributions to generating questionnaire of end user needs*.

[15] European Climate Adaptation Platform. Climate-ADAPT. [available at: http://climate-adapt.eea.europa.eu/glossary; accessed 13.02. 2016].

[16] European Maritime Safety Agency. *Annual overview of marine casualties and incidents 2014* [available at: www.emsa.europa.eu/emcip/download/3149/2303/23.html].

[17] European Maritime Safety Agency. *EU Mar Taxonomy* [available at: www.emsa.europa.eu/emcip/download/887/73/23.html; accessed 13.02. 2016].

[18] European Union, European Commission. (2013). Commission Staff working document: *Adapting infrastructure to climate change*, SWD(2013)137 final. Brussels.

[19] Federal Maritime and Hydrographic Agency of Germany. (2010). Information by Nico Nolte.

[20] Government of Canada. *Climate glossary* [available at: http://climate.weather.gc.ca/glossary_e.html; accessed 13.02. 2016].

[21] Guze, S. & Ledóchowski, M. (2016). Ship Traffic and Port Operation Information Critical Infrastructure Network. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7, 2, 65-72.

[22] HELCOM. (2009). Eutrophication in the Baltic Sea. An integrated thematic assessment of the effects of nutrient enrichment in the Baltic Sea region. *Balt. Sea Environ. Proc*. 115B.
[23] IMO. (2008). *Casualty-related matters reports on marine casualties and incidents*. MSC-MEPC.3/Circ.3, London.
[24] IPCC. (2014). Annex II: Glossary. Mach, K.J., Planton, S. & von Stechow, C. (Ed.). In: *Climate change 2014: synthesis report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. & Meyer, L.A. (Ed.). Geneva, Switzerland, 117-130.
[25] IPCC. (2007). *Climate change 2007: impacts, adaptation and vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani, O.F., Palutikof, J.P. et al. (Ed.). Cambridge University Press, Cambridge, UK.
[26] IPCC. (2012). Summary for policymakers. In: *Managing the risks of extreme events and disasters to advance climate change adaptation*. Field, C.B., Barros, V., Stocker, T.F. et al. (Ed.). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 1-19.
[27] Kołowrocki, K. (2016). Conclusions from the workshop on Baltic Sea region critical infrastructure networks and next steps in EU-CIRCLE project research. *Journal of Polish Safety and Reliability Association, Summer Safety and Reliability Seminars* 7, 2, 73-82.
[28] Moteff, J., Copeland, C. & Fischer, J. (2003). *Critical infrastructures: what makes an infrastructure critical?* Report for Congress. Congressional Research Service. The Library of Congress.
[29] Rinaldi, S.M., Peerenboom, J.P. & Kelly, T.K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. *IEEE Control Systems Magazine*, 11-25.
[30] Singh, A.K. & Singh, N.P. (2004). *Agricultural terminology*. Concept Publishing Co. New-Delhi-110059.
[31] Slandail terminology. *The Slandail project's disaster lexicon.* [available at: http://slandail terminology.pbworks.com/; accessed 13.02. 2016].
[32] The Global Facilitation Partnership for Transportation and Trade. Maritime Transport and Port Operations. [available at: http://www.gfptt. org/node/67; accessed 13.02. 2016].
[33] U.S. Department Homeland Security. (2013). *National infrastructure protection program. Partnering for critical infrastructure security and resilience*.
[34] U.S. Environmental Protection Agency. *Glossary of climate change terms*. [available at: http://www3. epa.gov/climatechange/glossary.html; accessed 13.02.2016].
[35] U.S. President's Commission on Critical Infrastructure Protection. (1997). *Critical Foundations: protecting America's infrastructures*.
[36] United Nations International Strategy for Disaster Reduction. (2009). *UNISDR Terminology on disaster risk reduction* [available at: http://www. unisdr.org/we/inform/terminology; accessed 13.02.2016].
[37] World Meteorological Organization. *International meteorological vocabulary*, WMO 182 [available at: http://wmo.multicorpora.net/MultiTransWeb/ Web.mvc; accessed 13.02.2016].