International Journal of Safety Science
Vol. 02, No. 01, (2018), pp. 74-83
DOI:10.24900/ijss/02017483.2018.0301

Special Issue Article: The 5th European STAMP Workshop (ESW) 2017, Chief Editor: Svana Helen Björnsdottir, Reykjavik University

Maritime Spatial Planning as a tool for ecosystem-based adaptive safety management of maritime transportation system in the Gulf of Finland (Baltic Sea)

Robert Aps*[1], Mihhail Fetissov[2], Floris Goerlandt[3], Pentti Kujala[3], Are Piel[4], John Thomas[5]

[1]University of Tartu, Estonian Marine Institute, Mäealuse 14, 12618 Tallinn, Estonia

[2]Aalto University, School of Engineering, Department of Applied Mechanics, Marine Technology, Research Group on Maritime risk and Safety, P.O. Box 12200, FI00076 Espoo, Finland

[3]Estonian Maritime Administration, Vessel Traffic Management Department, Valge 3, 11413 Tallinn, Estonia

[4]Massachusetts Institute of Technology, School of Engineering, 77 Massachusetts Avenue, Building E40-242, Cambridge, Massachusetts 02139-4307, USA

*[*1]robert.aps@ut.ee, [1]mihhail.fetissov@ut.ee, [2]floris.goerlandt@aalto.fi, [2]pentti.kujala@aalto.fi, [3]Are.Piel@vta.ee, [4]jthomas4@mit.edu*

Abstract

The Maritime Spatial Planning (MSP) is becoming an increasingly important tool for adaptive safety management of maritime transportation system (MTS) being ecosystem-based, integrated, place-based or area-based, adaptive, strategic, anticipatory and participatory iterative process. At the same time the rapid developments in ship intelligence are transforming the future of marine operations and are adding the new complexity to adaptive safety management of MTS. In this study in progress the ships' routing design is considered to be an important safety-critical element of ecosystem-based transboundary MSP solutions in the Gulf of Finland sea area. The STPA hazard analysis methodology is applied to identify ships' routing design related system level hazards, corresponding safety constraints and the potentially unsafe control actions that may lead to ships' routing hazardous design. To avoid ships' routing hazardous design flaws the implementation of safety-guided design is suggested with aim to embed the cost-effective safety effort into the ships' routing design process from the very beginning and to design safety into the system as the design decisions are made.

Keywords: *Maritime Spatial Planning, maritime transportation system, STPA, ships' routing, safety-guided design, Gulf of Finland, Baltic Sea*

1. Introduction

The International Maritime Organization (IMO) defines the Baltic Sea Area as a globally unique and sensitive brackish-water ecosystem vulnerable to damage by international shipping activities - more than 2,000 ships are *en route* in the area on an average day, not including ferries, smaller fishing vessels or leisure craft [1]. Being aware of its ecological, social, economic, cultural, scientific and educational value the Baltic Sea Area was designated as a Particularly Sensitive Sea Area (PSSA) by IMO Marine Environment Protection Committee in 2005. Addressing the environmental concerns the Mandatory

*Corresponding author robert.aps@ut.ee

Ship Reporting System in the Gulf of Finland Traffic Area (GOFREP) was established by IMO [2, 3] in 2003 and has been in effective operation since 2004 [4].

The basic tenet of an ecosystem-based approach is that conserving ecosystem functions and integrity is vital because viable ecosystems are the basic life support system for human communities [5]. HELCOM Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area [6] defines the ecosystem approach as “the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity”.

The EU Directive establishing a framework for maritime spatial planning [7] defines objectives of maritime spatial planning (MSP) as follows “When establishing and implementing maritime spatial planning, Member States shall consider economic, social and environmental aspects to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach, and to promote the coexistence of relevant activities and uses. Through their maritime spatial plans, Member States shall aim to contribute to the sustainable development of energy sectors at sea, of maritime transport, and of the fisheries and aquaculture sectors, and to the preservation, protection and improvement of the environment, including resilience to climate change impacts”.

According to IMO General Provisions on Ships’ Routing (GPSR) [8] the purpose of ships' routing is to improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited by restricted sea-room, the existence of obstructions to navigation, limited depths or unfavorable meteorological conditions and the routing system is defined as any system of one or more routes or routing measures aimed at reducing the risk of casualties including the traffic separation schemes, two-way routes, recommended tracks, areas to be avoided, inshore traffic zones, roundabouts, precautionary areas and deep water routes.

A System Theoretic Accident Modelling and Processes (STAMP) approach to operational safety management, originally developed for software and space engineering applications [9], considers accident occurrence as the result of a lack of, or inadequate enforcement of, constraints imposed on the system design and operations at various system levels. This novel to maritime domain approach is used to outline STAMP based dynamic safety management of eco-socio-technical maritime transport system [10] and STAMP-Mar based safety management of maritime navigation in the Gulf of Finland [11]. The STAMP based Systems Theoretic Process Analysis (STPA) [9, 12] as a powerful new hazard analysis method designed to go beyond traditional safety techniques has been successfully applied e.g. to space engineering applications [13] as well as to analysis of maritime traffic safety in the Gulf of Finland [14].

In this study in progress the ships’ routing design is considered to be an important safety-critical element of ecosystem-based transboundary MSP solutions in the Gulf of Finland sea area. The STPA hazard analysis methodology is applied to identify ships’ routing design related system level hazards, corresponding safety constraints and the potentially unsafe control actions that may lead to ships’ routing hazardous design. The ships’ routing design not meeting the IMO GPSR safety requirements is identified as the system-level hazard and the IMO GPSR design criteria are considered to be the system safety constraints to be imposed on the ships’ routing design.

2. Mandatory ship reporting system in the Gulf of Finland (GOFREP)

Referring to IMO [2] "The mandatory ship reporting system in the Gulf of Finland covers the international waters in the Gulf of Finland. In addition, Estonia and Finland have implemented mandatory ship reporting systems to their national water areas outside VTS areas. These reporting systems provide same services and make same requirements to shipping as the system operating in the international waters. The mandatory ship reporting system and the Estonian and Finnish national mandatory ship reporting systems are together referred as the GOFREP and their area of coverage respectively as the GOFREP area" (Figure 1).

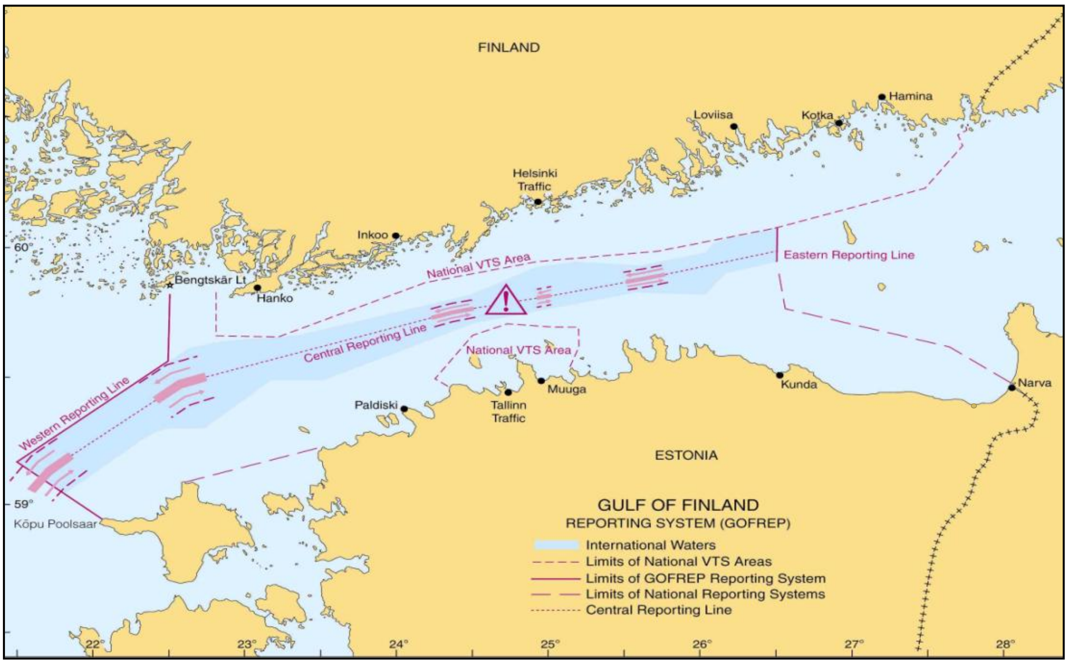

Figure 1. The mandatory ship reporting system in the Gulf of Finland (source: Estonian Maritime Administration)

According to IMO [3] ships of 300 gross tonnage and over are required to participate in the GOFREP system while ships under 300 gross tonnage should make reports in circumstances where they 1) are not under command or at anchor in the Traffic Separation Scheme (TSS), 2) are restricted in their ability to maneuver, and 3) have defective navigational aids.

The GOFREP maritime traffic control system is jointly managed by the Finnish Transport Agency, Estonian Maritime Administration and the Federal Agency for Maritime and River Transport of Russian Federation and is based on the activities of GOFREP Traffic Centers of Estonia (Tallinn Traffic), Finland (Helsinki Traffic) and the Russian Federation VTMIS Centre in Petrodvorets (Saint Petersburg Traffic).

The GOFREP Traffic Centre operator is able to observe the controlled maritime traffic process through the radar and AIS surveillance of traffic in the Ship Reporting System (SRS) area, and to actuate the process if the vessels under control proceed against International Regulations for Preventing Collisions at Sea, 1972 as amended (COLREGS).

3. IMO General Provisions on Ships' Routing

The main objectives of the ships' routing systems as defined by IMO [15] are: "1) the separation of opposing streams of traffic so as to reduce the incidence of head-on encounters, 2) the reduction of dangers of collision between crossing traffic and shipping in established traffic lanes, 3) the simplification of the patterns of traffic flow in converging areas, 4) the organization of safe traffic flow in areas of concentrated offshore exploration or exploitation, 5) the organization of traffic flow in or around areas where navigation by all ships or by certain classes of ship is dangerous or undesirable, 6) the organization of safe traffic flow in or around or at a safe distance from environmentally sensitive areas, 7) the reduction of risk of grounding by providing special guidance to vessels in areas where water depths are uncertain or critical, and 8) the guidance of traffic clear of fishing grounds or the organization of traffic through fishing grounds".

It is generally recognized that the Baltic Sea offers a wealth of resources that can be sustainably utilized to harvest energy while ensuring that energy interests can coexist with other spheres of activity. The offshore energy production is considered to be one of the main drivers of MSP in the Baltic Sea Region. According to IMO [16] in planning to establish multiple structures at sea, including but not limited to wind turbines "Governments should take into account, as far as practicable, the impact these could have on the safety of navigation, including any radar interference. Traffic density and prognoses, the presence or establishment of routeing measures in the area, and the manoeuvrability of ships and their obligations under the 1972 Collision Regulations should be considered when planning to establish multiple structures at sea. Sufficient manoeuvring space extending beyond the side borders of traffic separation schemes should be provided to allow evasive manoeuvres and contingency planning by ships making use of routeing measures in the vicinity of multiple structure areas".

The IMO Maritime Safety Committee, with a view to ensuring the proper development, drafting, and submission of proposals for ships' routing systems and ship reporting systems, approved a Guidance Note on the Preparation of Proposals on Ships' Routing Systems and Ship Reporting Systems [17]. Referring to proposals intended to protect the marine environment, the proposal should state whether the proposed routing system can reasonably be expected to significantly prevent or reduce the risk of pollution or other damage to the marine environment of the area concerned.

Several ships' routing measures are established in the GOFREP sea area (Figure 2):
1) Deep-water route - a route within defined limits which has been accurately surveyed for clearance of sea bottom and submerged obstacles as indicated on the chart,
2) Traffic separation scheme - a routing measure aimed at the separation of opposing streams of traffic by appropriate means and by the establishment of traffic lanes,
3) Traffic separation zone or line - a zone or line separating the traffic lanes in which ships are proceeding in opposite or nearly opposite directions; or separating a traffic lane from the adjacent sea area; or separating traffic lanes designated for particular classes of ship proceeding in the same direction,
4) Traffic lane - an area within defined limits in which one-way traffic is established; natural obstacles, including those forming separation zones, may constitute a boundary,
5) Roundabout - a routing measure comprising a separation point or circular separation zone and a circular traffic lane within defined limits; traffic within the roundabout is separated by moving in a counter clockwise direction around the separation point or zone,
6) Precautionary area - a routing measure comprising an area within defined limits where ships must navigate with particular caution and within which the direction of traffic flow may be recommended.

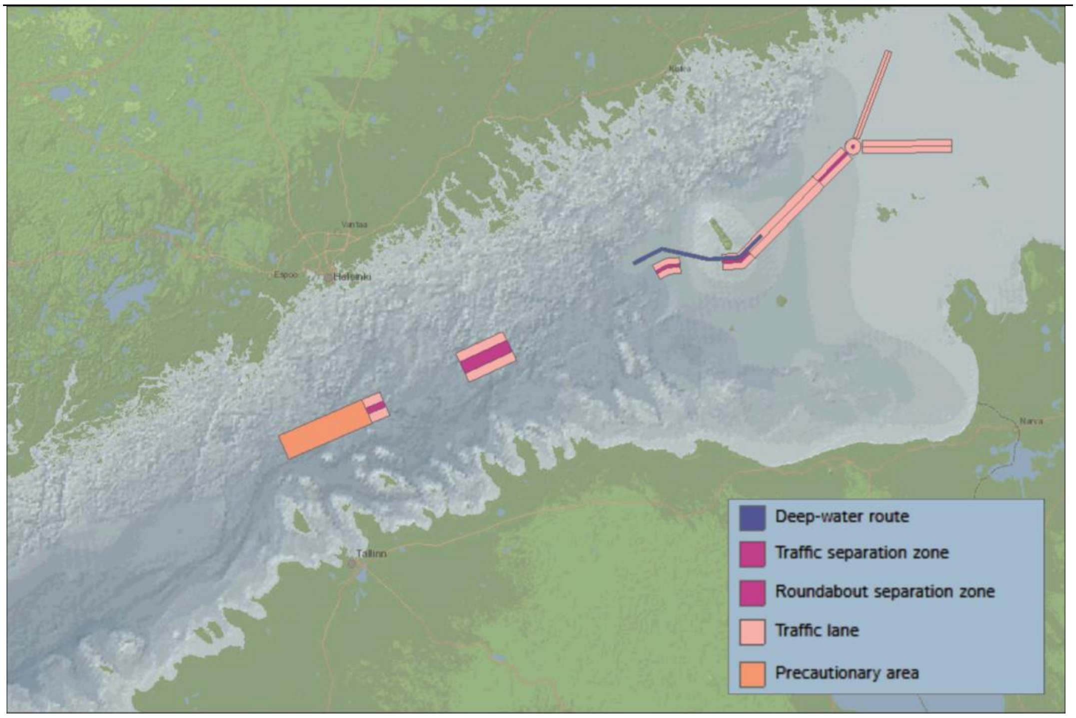

Figure 2. Ships' routing measures established in the GOFREP sea area (source: HELCOM http://maps.helcom.fi/website/mapservice/)

Referring to IMO [15] the routing system selected for a particular area should aim at providing safe passage for ships through the area without unduly restricting legitimate rights and practices, and taking account of anticipated or existing navigational hazards. It is stated further that when planning, establishing, reviewing or adjusting a routing system, the following factors shall be taken into account: 1) the rights and practices in respect of the exploitation of living and mineral resources, 2) previously established routing systems in adjacent waters, whether or not under the proposing Government's jurisdiction, 3) the existing traffic pattern in the area concerned, including coastal traffic, crossing traffic, naval exercise areas and anchorage areas, 4) foreseeable changes in the traffic pattern resulting from port or offshore terminal developments, 5) the presence of fishing grounds, 6) existing activities and foreseeable developments of offshore exploration or exploitation of the sea-bed and subsoil, 7) the adequacy of existing aids to navigation, hydrographic surveys and nautical charts of the area, 8) environmental factors, including prevailing weather conditions, tidal streams and currents and the possibility of ice concentrations, and 9) the existence of environmental conservation areas and foreseeable developments in the establishment of such areas.

4. STPA hazard analysis

In this study the STPA hazard analysis is performed on the STAMP-Mar functional control diagram of the ships' routing design processes (Figure 3). In a course of STPA hazard analysis applied to the ships' routing design processes the accident is specified as an undesired and unplanned environmental and socio-economic loss event (e.g. ships' collision or running aground) caused by actual application of the ships' routing hazardous design. Ships' routing design not meeting the IMO GPSR safety requirements is identified as the system-level hazard and the IMO GPSR design criteria are considered to be the system safety constraints to be imposed on the ships' routing design.

Ships' routing actual design starts after the hazards and system-level safety requirements and constraints have been identified and it is carried out according to rules [16] on development, drafting, and submission of proposals to IMO for ships' routeing systems setting forth the issues that should be included in such proposals to facilitate their assessment and approval by the Sub-Committee on Safety of Navigation (NAV) and final adoption by the Maritime Safety Committee (MSC). It is further added that when developing a proposal, the IMO Member Governments should in particular consult the GPSR for the definition of the type of system desired, the method for establishing that particular type of system, and, if the system is a traffic separation scheme or a deep-water route, including the specific information pertaining to those types of systems.

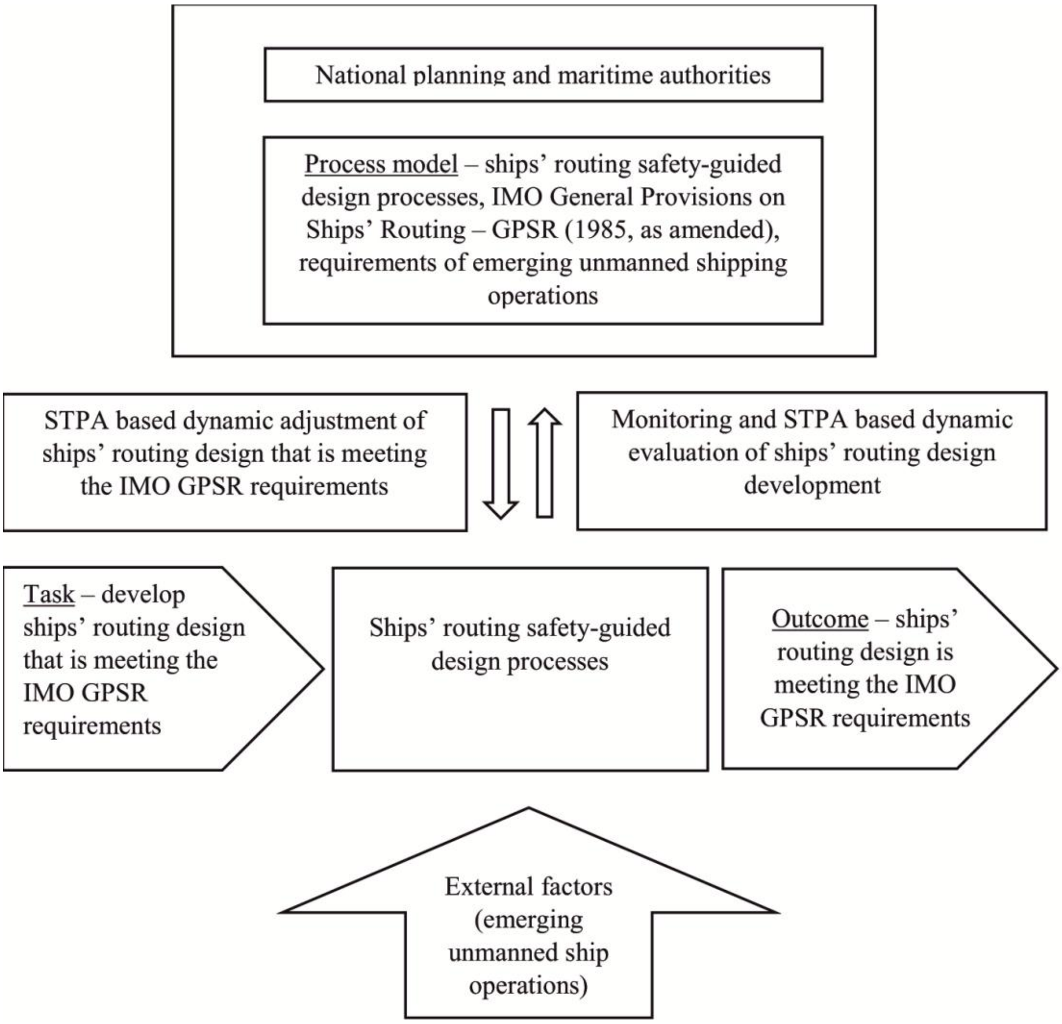

Figure 3. STAMP-Mar functional control diagram of the ships' routing safety-guided design processes (modified from [9])

The mainstream use of unmanned, remote-controlled or autonomous vessels may very well be the future of commercial shipping [18]. This technological advancement is adding the new requirements to maritime transportation safety management including the amendment of existing and development of new ships' routing measures being ecosystem based and meeting also the requirements of unmanned shipping operations. These are the external factors shown in the Figure 3.

The prototypes of unmanned merchant vessels are expected to come into service within the coming years and the introduction of the unmanned merchant vessels to the global

International Journal of Safety Science
Vol. 02, No. 01, (2018), pp. 74-83
DOI:10.24900/ijss/02017483.2018.0301

shipping industry appears to be only a matter of time, despite all social, legal and technological concerns [19]. It is suggested [20] that the implications of such technological advances are enormous and will require an amendment to the existing legal structures and regulations, perhaps paving way for a new regulatory regime to deal with liabilities.

Referring to [18] also existing conventions and laws that apply to commercial shipping can be adapted as needed and it is added that "… biggest adaptations would be considering a qualified remote crew the equivalent of a properly manned ship, a remote operator as the master of the ship, and the electronic sensor systems as their eyes and ears".

It is stated [19] that from the scarce body of literature in the field of unmanned shipping it is evident that one of major issues related to the unmanned ship operations is their safety while the main line of argument supporting their introduction pertains to the increase in navigational safety. Therefore, the development and implementation of the safe ships' routing design seems to be even more important in connection to navigational safety of emerging unmanned ship operations.

The ships' routing design related system-level hazards and safety constraints to be enforced are presented in Table 1.

Table 1. Ships' routing design related system level hazards and the safety constraints according to IMO General Provisions on Ships' Routing – GPSR (1985, as amended)

System level hazards related to ships' routing design	Ships' routing design related safety constraints according to IMO General Provisions on Ships' Routing – GPSR 1985, as amended)
Ships' routing design of course alterations along the route is not meeting the IMO GPSR requirements	Course alterations along a route should be as few as possible and should be avoided in the approaches to convergence areas and route junctions or where crossing traffic may be expected to be heavy
Ships' routing design of traffic separation schemes is not meeting the IMO GPSR requirements	Traffic separation schemes shall be designed so as to enable ships using them to fully comply at all times with the International Regulations for Preventing Collisions at Sea (COLREGs), 1972, as amended
Ships' routing design of maritime traffic lanes is not meeting the IMO GPSR requirements	Traffic lanes should be designed to make optimum use of available depths of water and the safe navigable areas, taking into account the maximum depth of water attainable along the length of the route. The width of lanes should take account of the traffic density, the general usage of the area and the sea-room available
Ships' routing design to allow optimum use of aids to navigation in the area is not meeting the IMO GPSR requirements	Routes should be designed to allow optimum use of aids to navigation in the area, and of such shipborne navigational aids as are required or recommended to be fitted by international conventions or by IMO resolutions and recommendations

As the first step of STPA, the potentially unsafe control actions that may lead to the ship's routing hazardous design are identified and presented in Table 2.

DOI:10.24900/ijss/02017483.2018.0301

Table 2. Potentially unsafe control actions that may lead to the ship's routing hazardous design

Control action required	Action required but not provided	Action provided unsafe	Action provided too late
Impose ships' routing safety constraints on design of course alterations along the route according to IMO GPSR	Hazardous design – ships' routing safety constraints on design of course alterations along the route according to IMO GPSR are not imposed	Hazardous design – ships' routing safety constraints on design of course alterations along the route according to IMO GPSR are not properly imposed	Hazardous design – ships' routing safety constraints on design of course alterations along the route according to IMO GPSR are not timely imposed
Impose ships' routing safety constraints on design of traffic separation schemes according to IMO GPSR	Hazardous design – ships' routing safety constraints on design of traffic separation schemes according to IMO GPSR are not imposed	Hazardous design – ships' routing safety constraints on design of traffic separation schemes according to IMO GPSR are not properly imposed	Hazardous design – ships' routing safety constraints on design of traffic separation schemes according to IMO GPSR are not timely imposed
Impose ships' routing safety constraints on design of maritime traffic lanes according to IMO GPSR	Hazardous design – ships' routing safety constraints on design of maritime traffic lanes according to IMO GPSR are not imposed	Hazardous design – ships' routing safety constraints on design of maritime traffic lanes according to IMO GPSR are not properly imposed	Hazardous design – ships' routing safety constraints on design of maritime traffic lanes according to IMO GPSR are not timely imposed
Impose ships' routing safety constraints on design to allow optimum use of aids to navigation in the area according to IMO GPSR	Hazardous design – ships' routing safety constraints on design to allow optimum use of aids to navigation in the area according to IMO GPSR are not imposed	Hazardous design – ships' routing safety constraints on design to allow optimum use of aids to navigation in the area according to IMO GPSR are not properly imposed	Hazardous design – ships' routing safety constraints on design to allow optimum use of aids to navigation in the area according to IMO GPSR are not timely imposed

The second step of STPA hazard analysis is performed on a STAMP-Mar functional control diagram of the ships' routing design processes (Figure 3) with aim to identify the causal factors for potentially hazardous control actions based on expert interviews and discussions. It was suggested by experts that without systems approach the hazard analysis may sometimes be performed after the major design decisions on ships' routing design have been done and as a consequence not all potential and hidden hazards are identified and designed out of the system.

With aim to avoid ships' routing hazardous design flaws the implementation of safety-guided design is suggested with aim to embed the cost-effective safety effort into the ships' routing design process from the very beginning and to design safety into the system as the design decisions are made. Therefore it is suggested to use STPA in a proactive way guiding the ships' routing design by integrating the design and hazard analysis into the safety-guided design processes.

Referring to [21] the MSP is becoming an increasingly important tool for adaptive safety management of maritime transportation being ecosystem-based, integrated, place-based or area-based, adaptive, strategic, anticipatory and participatory iterative process. Thereby the objective is to integrate the issues that are most vital to maritime transportation - safety, continued operation, business success and efficiency of sustainable maritime transportation system into the MSP options. At that the practical implementation of the STAMP concept enables planners and the stakeholders to integrate the monitoring and evaluation functions directly into the actual maritime spatial planning processes [10].

It is stated [22] that the MSP process should result in a plan that lead to organizing and regulating the human uses of the seas while protecting marine ecosystems and deliver the ecosystem services and societal benefits. The *Ten tenets* of Elliott are suggested as the quality objectives of the plan (QOP) reflecting what the MSP process should achieve [23]. Based on that the integrated and holistic planning solutions should be: 1) environmentally/ecologically sustainable, 2) technologically feasible, 3) economically viable, 4) socially desirable/tolerable, 5) legally permissible, 6) administratively achievable, 7) politically expedient, 8) ethically defensible, 9) culturally inclusive, and 10) effectively communicable.

Based on this study it is suggested to use STPA in a proactive way guiding the maritime spatial planning processes including the ships' routing design by integrating the planning options hazard analysis into the safety-guided MSP development. It is further suggested to use the *Ten tenets* of Elliott for integrated, successful and sustainable maritime management as the safety constraints to be satisfied in a course of ecosystem based development and implementation of the integrated transboundary maritime planning solutions in terms of environment, legislation, policies, governance, cultural, social, economic, and technological considerations.

9. Conclusions

As defined by IMO the purpose of ships' routing is to improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited by restricted sea-room, the existence of obstructions to navigation, limited depths or unfavorable meteorological conditions.

The STPA hazard analysis methodology is applied to identify ships' routing design related system level hazards, corresponding safety constraints and the potentially unsafe control actions that may lead to ships' routing hazardous design.

To avoid ships' routing hazardous design flaws the implementation of safety-guided design is suggested with aim to embed the cost-effective safety effort into the ships' routing design process from the very beginning and to design safety into the system as the design decisions are made. Therefore it is suggested to use STPA in a proactive way guiding the ships' routing design by integrating the design and hazard analysis into the safety guided design processes.

It is suggested to use STPA in a proactive way guiding the maritime spatial planning processes including the ships' routing design by integrating the planning options hazard analysis into the safety-guided MSP development. It is further suggested to use the *Ten tenets* of Elliott for integrated, successful and sustainable maritime management as the safety constraints to be satisfied in a course of ecosystem based development and implementation of the integrated transboundary maritime planning solutions.

Acknowledgments

This work resulted from the BONUS project "Strategic and operational risk management for wintertime maritime transportation system (BONUS STORMWINDS)". The project was supported by BONUS (Art 185), funded jointly by the EU and the national funding institutions: the Academy of Finland (Finland), the Estonian Research Council (Estonia), the Research Council for Environment Agricultural Sciences and Spatial Planning (FORMAS) (Sweden).

References

[1] IMO, Designation of the Baltic Sea area as a particularly sensitive sea area. Resolution MEPC.136 (53), (2005).

[2] IMO, Mandatory Ship Reporting Systems SN.1/Circ.258, International Maritime Organization, London, (2006).

[3] IMO, Mandatory Ship Reporting Systems SN/Circ.225, International Maritime Organization, London, (2003).

[4] S. Sonninen, M. Nuutinen, T. Rosqvist, Development process of the Gulf of Finland mandatory ship reporting system - reflections on the methods, VTT Publications 614, Espoo, (2006), 124 p.

[5] S. Leech, A. Wiensczyk, J. Turner, "Ecosystem management: A practitioners' guide", BC Journal of Ecosystems and Management, vol. 10, no. 2 (2009), pp. 1–12.

[6] HELCOM, Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area, (2016).

[7] EC, Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (2008).

[8] IMO, General provisions on ships' routing, Res. A.572 (14), (1985).

[9] N. Leveson, Engineering a safer world - Systems theory applied to safety. Cambridge, MA, MIT Press, (2011).

[10] R. Aps, M. Fetissov, F. Goerlandt, J. Helferich, M. Kopti, P. Kujala, Towards STAMP based dynamic safety management of eco-sociotechnical maritime transport system, Procedia Engineering, 128, (2015), pp. 64 – 73.

[11] R. Aps, M. Fetissov, F. Goerlandt, M. Kopti, P. Kujala, STAMP-Mar based safety management of maritime navigation in the Gulf of Finland (Baltic Sea), European Navigation Conference 2016, Helsinki, 30 May-2 June 2016, IEEE Xplore, (2016), pp. 1−8.

[12] J.P. Thomas, Extending and Automating a Systems-Theoretic Hazard Analysis for Requirements Generation and Analysis, Sandia Report SAND2012-4080, Sandia National Laboratories, (2012).

[13] T. Ishimatsu, N. Leveson, J. Thomas, C. Fleming, M. Katahira, Y. Miyamoto, R. Ujiie, H. Nakao, N. Hoshino, Hazard Analysis of Complex Spacecraft Using Systems-Theoretic Process Analysis, Journal of Spacecraft and Rockets, 51 (2), (2014) pp. 509–522.

[14] R. Aps, M. Fetissov, F. Goerlandt, P. Kujala, A. Piel, Systems-Theoretic Process Analysis of maritime traffic safety management in the Gulf of Finland (Baltic Sea), Procedia Engineering, 179, Elsevier, (2017) pp. 2-12.

[15] IMO, Ships' Routing, consolidated edition, (2008).

[16] IMO, Amendments to the general provisions on ships' routing, (MSC.419 (97), (2016).

[17] IMO, Guidance Note on the preparation of proposals on ships' routing systems and ship reporting systems, MSC/Circ.1060, (2003).

[18] D. Kaminski, Who's to blame when no one is manning the ship? Zelle LLP, Shipping Law News 06/10/2016, (2017).

[19] K. Wróbel, J. Montewka, P. Kujala, Towards the assessment of potential impact of unmanned vessels on maritime transportation safety, Reliability Engineering and System Safety, 165, (2017), pp. 155–169.

[20] H. F. Willan, Autonomy at sea – the future? April 2017. Shipping Law News 01/05/2017, (2017).

DOI:10.24900/ijss/02017483.2018.0301

[21] D. Patraiko, P. Holthus, The shipping industry and Marine Spatial Planning - a Professional Approach, The Nautical Institute and the World Ocean Council, (2013).

[22] M. Elliott, Marine science and management means tackling exogenic unmanaged pressures and endogenic managed pressures – a numbered guide. Mar. Pollut. Bull., 62, (2011), 651–655.

[23] R. Cormier, A. Kannen, M. Elliott, P. Hall, Marine Spatial Planning Quality Management System, ICES Cooperative Research Report, No. 327, (2015).