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


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STORMWINDS

Strategic and operational risk management for wintertime maritime transportation system

# The STAMP-Mar Research Concept

# Safety management of eco-socio-technical systems

- Systems Theoretic Accident Models and Processes (STAMP) is extended beyond the area of socio-technical systems safety into realm of complex eco-socio-technical systems safety
- The integrated safety management of holistic eco-socio-technical system builds on the monitoring of environmental performance of maritime traffic and port operations including accident response activities, and on the feedback based appropriate corrective management actions

(Aps et al., 2015)

# The STAMP-Mar research concept

- The STAMP-Mar research concept and application positions under development are aimed at dynamic safety management of eco-socio-technical maritime navigation system that will network existing systems, systems already under development, and systems to be developed to meet the system safety requirements and to enable high levels of joint connectivity, situational awareness and understanding.

(Aps et al., 2016)

# Regional Environmental Sensitivity Index (RESI)

- Regional Environmental Sensitivity Index (RESI) is used for STAMP-Mar based maritime navigation operational safety management as well as for setting the MSP processes related environmental constraints
- RESI is used as a factual basis also for establishing the environmental constraints for the STAMP-Mar standard control loop based maritime navigation safety control system in the Gulf of Finland

(Aps et al., 2016a)

# Systems-Theoretic Process Analysis (STPA)

- STPA has proved to be an effective and efficient method to assess the safety management of a complex safety-critical socio-technical system from the maritime domain
- Lessons learned show that STPA is an especially effective novel method to address the dynamic interactions between the integrated human and technical e-navigation components and, in general, is applicable to any navigable sea area in the world subject to IMO COLREGs

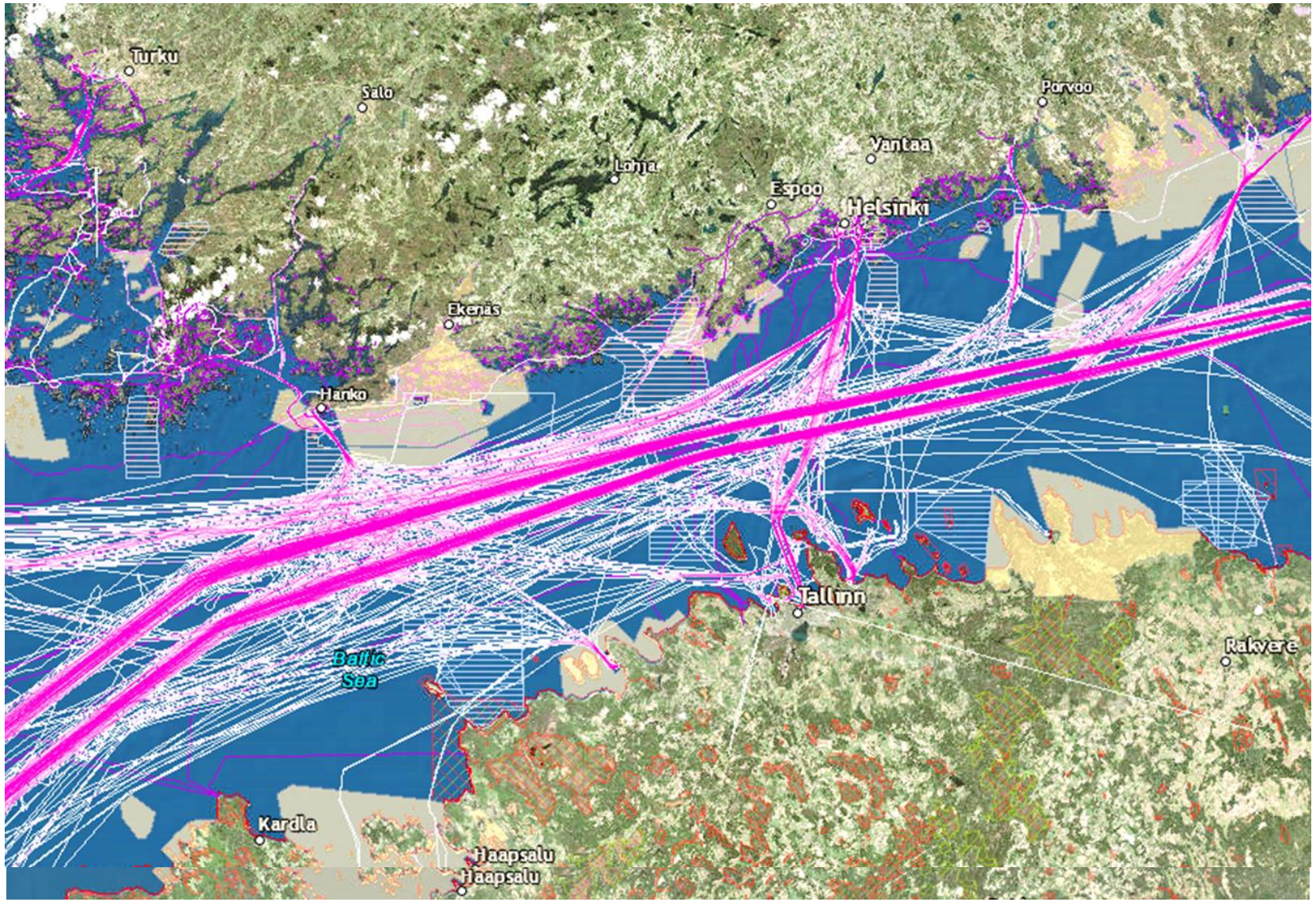
(Aps et al., 2016b)

# Study area

- According to International Maritime Organization (IMO) the Baltic Sea Area has some of the densest maritime traffic in the world. The Baltic Sea was designated as a Particularly Sensitive Sea Area (PSSA) at IMO Marine Environment Protection Committee's 53rd session in July 2005
- The Mandatory Ship Reporting System in the Gulf of Finland Traffic Area (GOFREP) was established by IMO in 2003 and has been in efficient operation since 2004

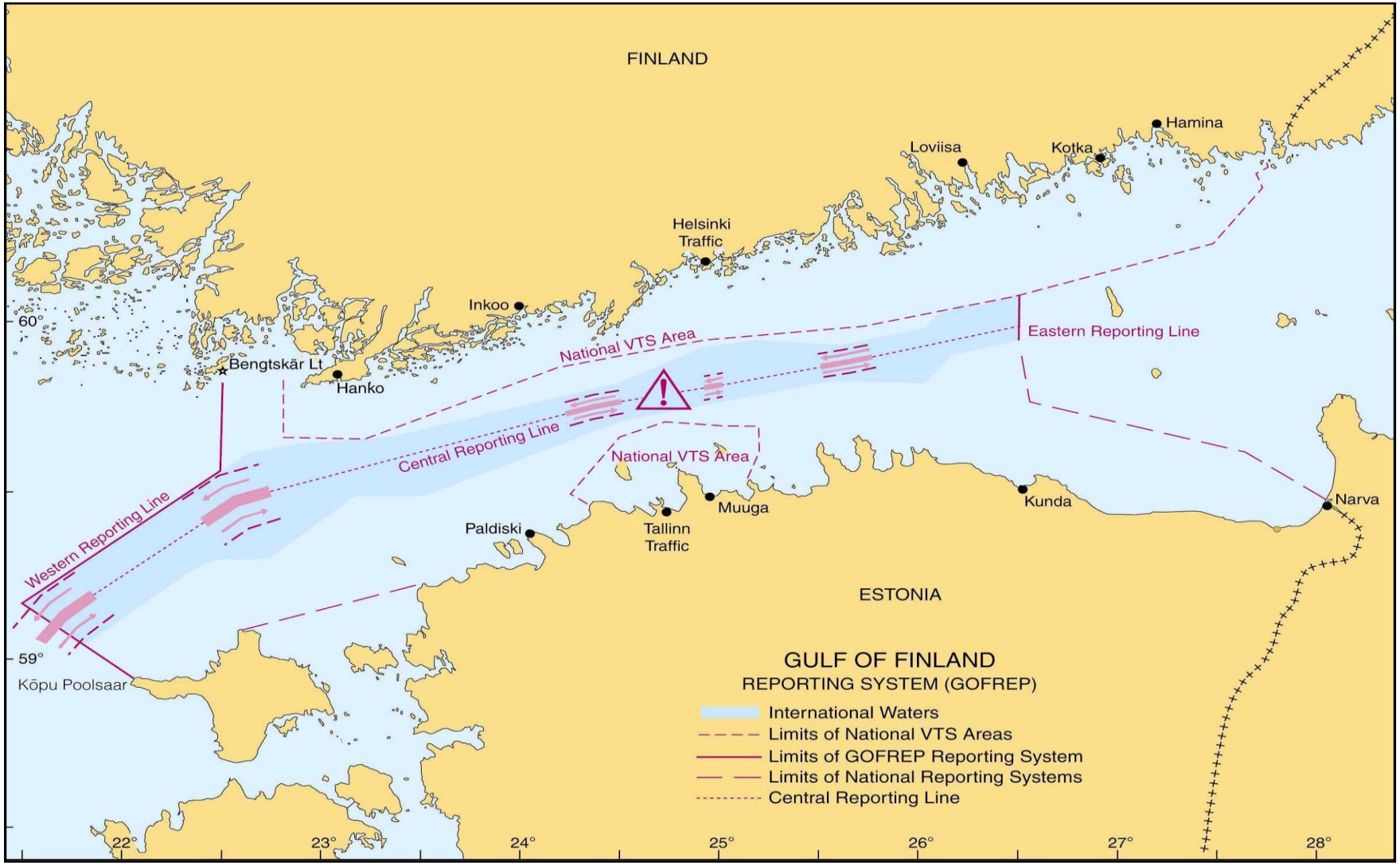
# The Gulf of Finland

# GOFREP area - sensitive environment and heavy maritime traffic



# The mandatory ship reporting system in the Gulf of Finland - GOFREP

(source: Estonian Maritime Administration)



# IMO General Provisions on Ships’ Routing

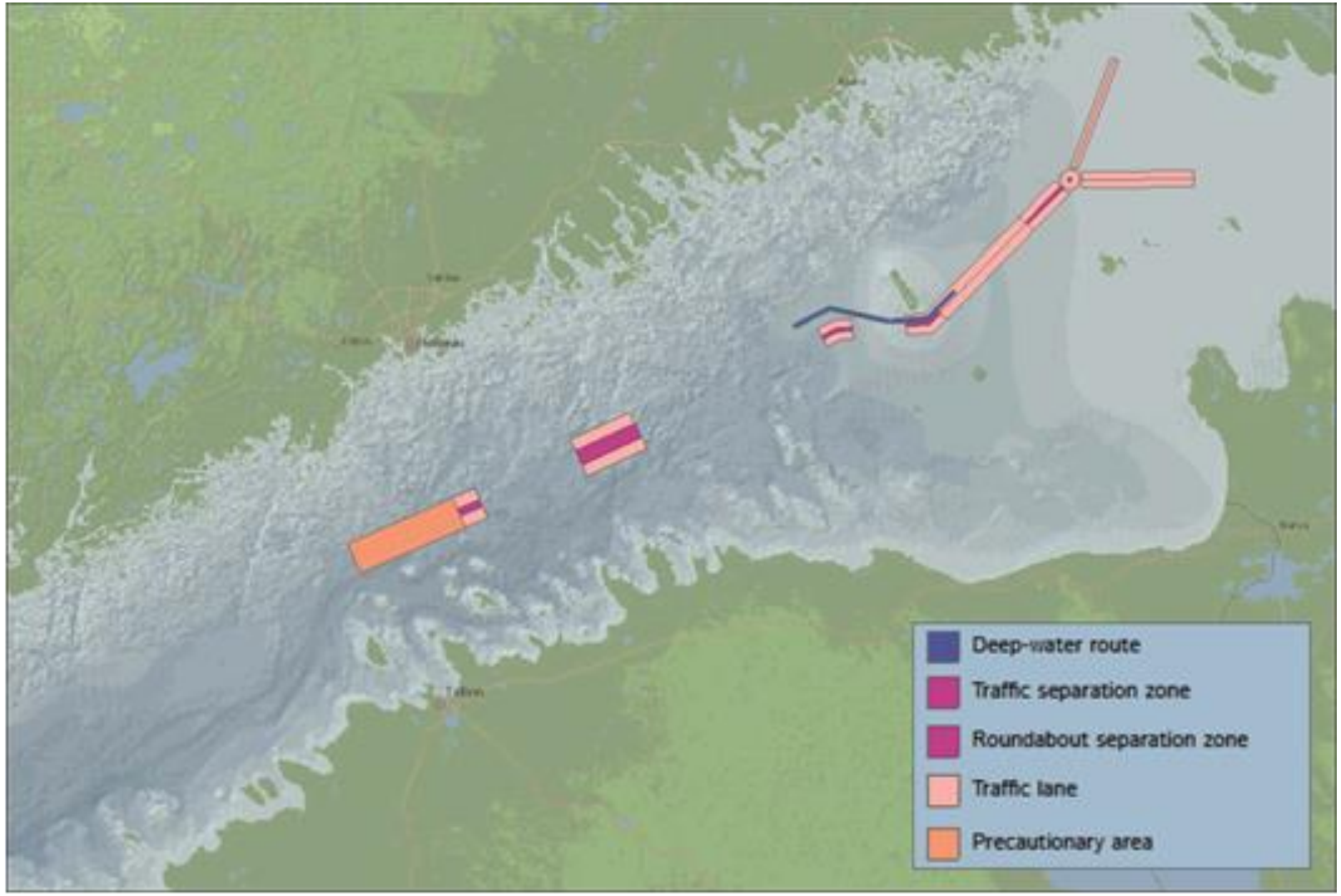
According to International Maritime Organizations' (IMO) General Provisions on Ships’ Routing (GPSR) the purpose of ships' routing is to improve the safety of navigation in converging areas and in areas where the density of traffic is great or where freedom of movement of shipping is inhibited by restricted sea-room, the existence of obstructions to navigation, limited depths or unfavorable meteorological conditions

# Ships' routing measures established in the GOFREP sea area

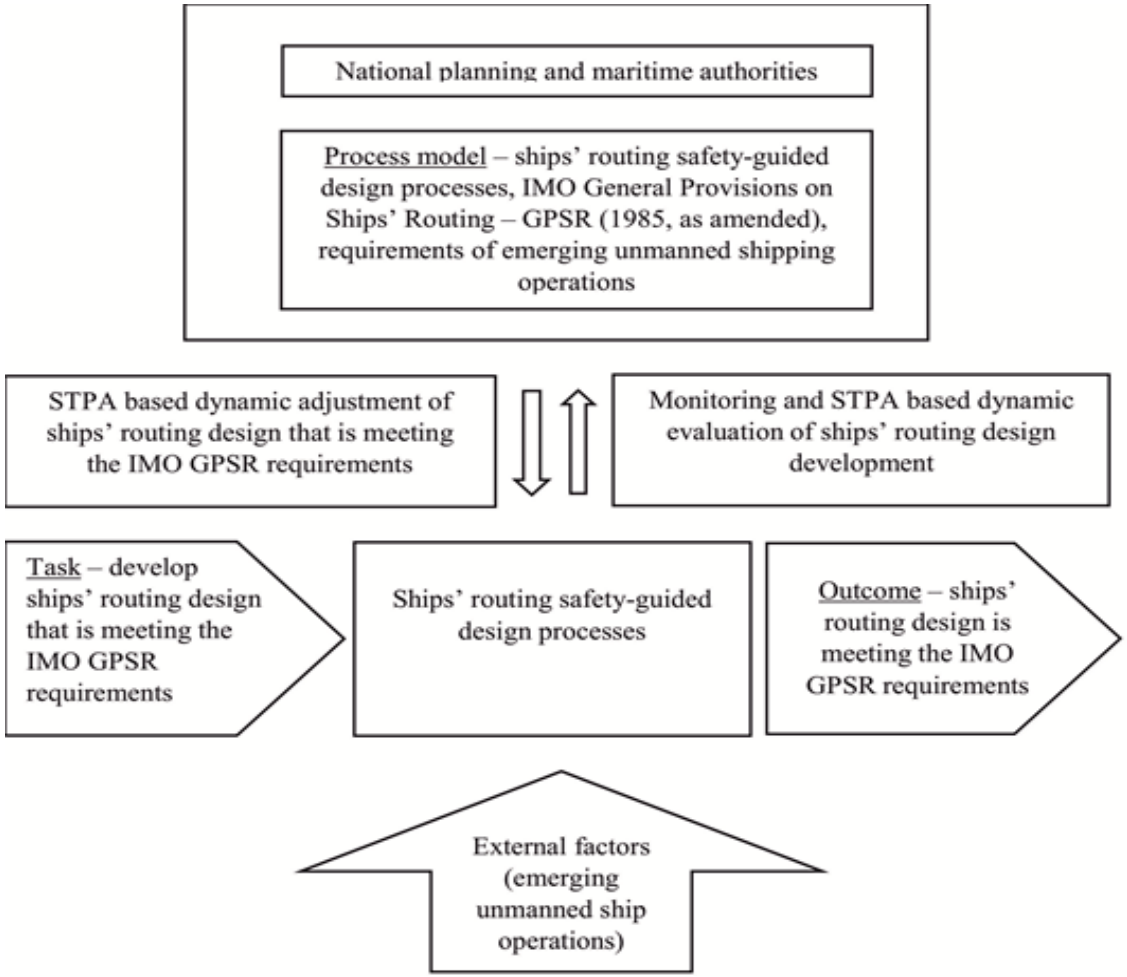
- **Deep-water route** - a route within defined limits which has been accurately surveyed for clearance of sea bottom and submerged obstacles as indicated on the chart
- **Traffic separation scheme** - a routing measure aimed at the separation of opposing streams of traffic by appropriate means and by the establishment of traffic lanes
- **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
- **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
- **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
- **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

# Ships' routing measures established in the GOFREP sea area

## (source: HELCOM http://maps.helcom.fi/website/mapservice/)



# STAMP-Mar functional control diagram of the ships' routing safety-guided design processes (modified from Leveson, 2011)



# Rapid developments in ship intelligence

- The rapid developments in ship intelligence are transforming the future of marine operations and are adding the new complexity 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 STAMP-Mar functional control diagram of the ships' routing safety-guided design processes

# Ships' routing design - important safety-critical element of ecosystem-based transboundary MSP solutions

**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 GPRS safety requirements is identified as the system-level hazard and**
- **The IMO GPRS design criteria are considered to be the system safety constraints to be imposed on the ships' routing design**

# 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**

# 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

- The second step of STPA hazard analysis is performed on a STAMP-Mar functional control diagram of the ships' routing design processes 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
- 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

# The future work

# The STAMP-Mar based Maritime Spatial Planning processes

- **The *Ten tenets* of Elliott (Cormier et al., 2015) are suggested as the quality objectives of the Maritime Spatial Plan (QOP) and referring to that the integrated and holistic planning solutions should be:**
- **environmentally/ecologically sustainable,**
- **technologically feasible,**
- **economically viable,**
- **socially desirable/tolerable,**
- **legally permissible,**
- **administratively achievable,**
- **politically expedient,**
- **ethically defensible,**
- **culturally inclusive, and**
- **effectively communicable**

# STPA based safety-guided MSP solutions

- Based on results of 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 solutions including the requirements of emerging unmanned, remote-controlled or autonomous shipping operations
- 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

**The future belongs to those who see the opportunities before they became the reality!**

**Stig Löfberg**

**The management is seen as the feedback based control process**

# Where to from here?

## Towards STAMP-Mar based sustainable marine management – the future is now!

# Acknowledgements

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STORMWINDS

Strategic and operational risk management
for wintertime maritime transportation system

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# Thank you very much for your attention!