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A Systemic Measuring and Modelling of Safety Management for Winter Navigation Operations

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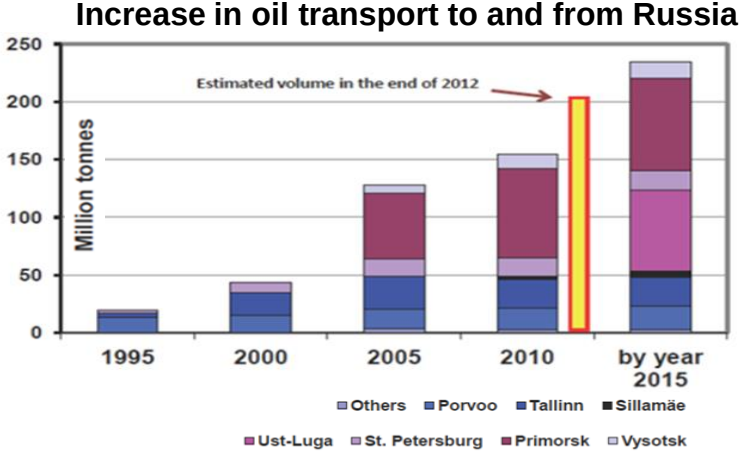
Motivation

In Finland, about 80% of the import and export of goods are transported by sea *(1).*

Traffic in areas such as Gulf of Finland is continuously growing due to the constant increase in the transportation of various cargoes to Russia and of oil from Russia *(2).*



1. Asplund and Malmberg (2011)
2. Kujala, P., Hänninen, M., Arola, T., Ylitalo, J., (2009). Reliab. Eng. Syst. Saf. 94, 1349–1357.

Motivation

The increment of ship traffic is also reflected during wintertime when ice is covering totally or partially the northern Baltic *(3)*.

The severity of the majority of the reported accidents during wintertime is mainly low. However, available and good quality accident information together with safety management guidance is lacking *(3)*.

Improvement risk and safety management guidance and training have recently be detected as actions needed to ensure the safety performance of winter navigation (4).

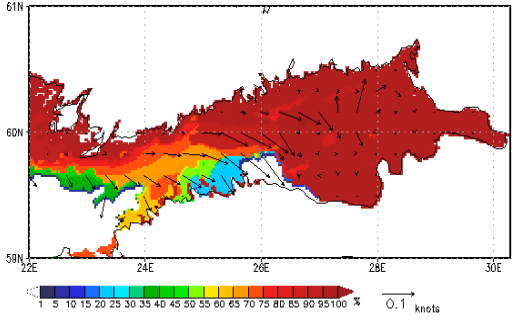
3. Valdez Banda O.A., Goerlandt F., Montewka J. and Kujala P. (2015) Accident Analysis and Prevention. 79 (100-116)
4. Valdez Banda O.A., Goerlandt F., Kujala P. and Montewka J. (2015) ESREL 2015. Zurich 6-10 of September 2015.

Background

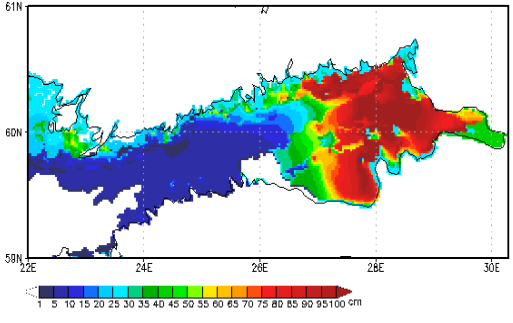
Ice conditions

Finnish maritime areas may experience several forms of floating and fast ice each winter, with the sea ice cover extending to the south from the Bay of Bothnia and to the west from the eastern Gulf of Finland.

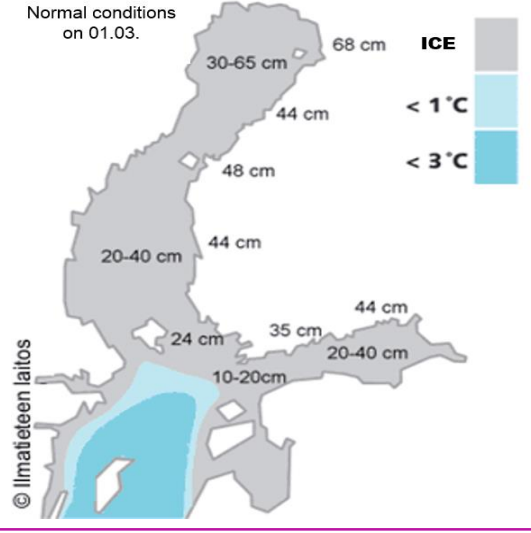
Ice concentration and drift



Mean ice thickness



Ice conditions in Finnish maritime areas



Ice conditions images by the Finnish Meteorological Institute (FMI, 2003)

Winter navigation operations

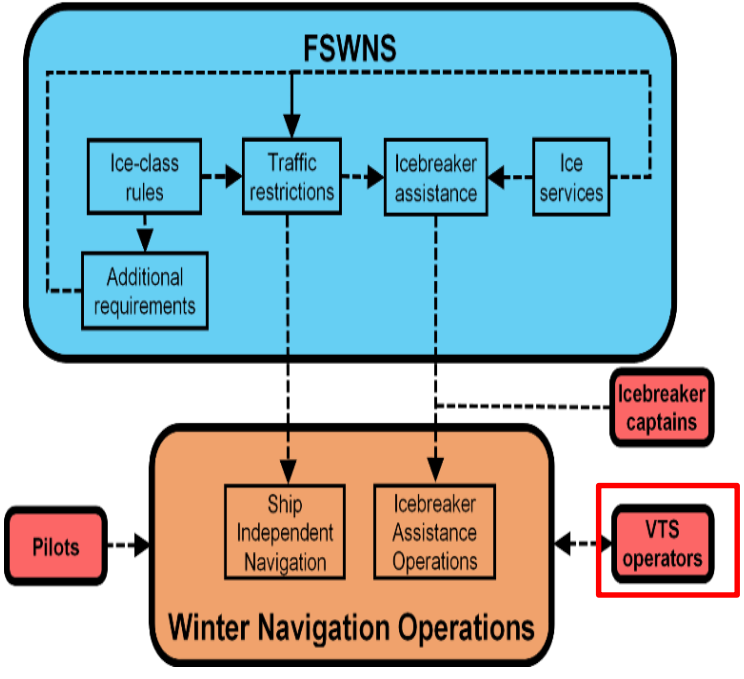
Independent navigation

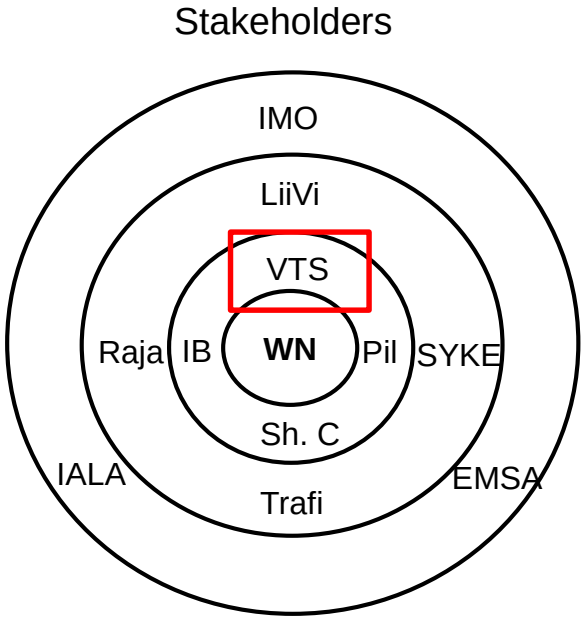
Convoy

Towing

Beset in ice

The Finnish-Swedish Winter Navigation System





VTS role in winter navigation operations.

Controlling and monitoring ships traffic and providing navigational guidance for the development of the winter navigation operations, the aim is ensuring the ships' safety and the protection of the natural environment.

Using STAMP to assess the safety performance of winter navigation.

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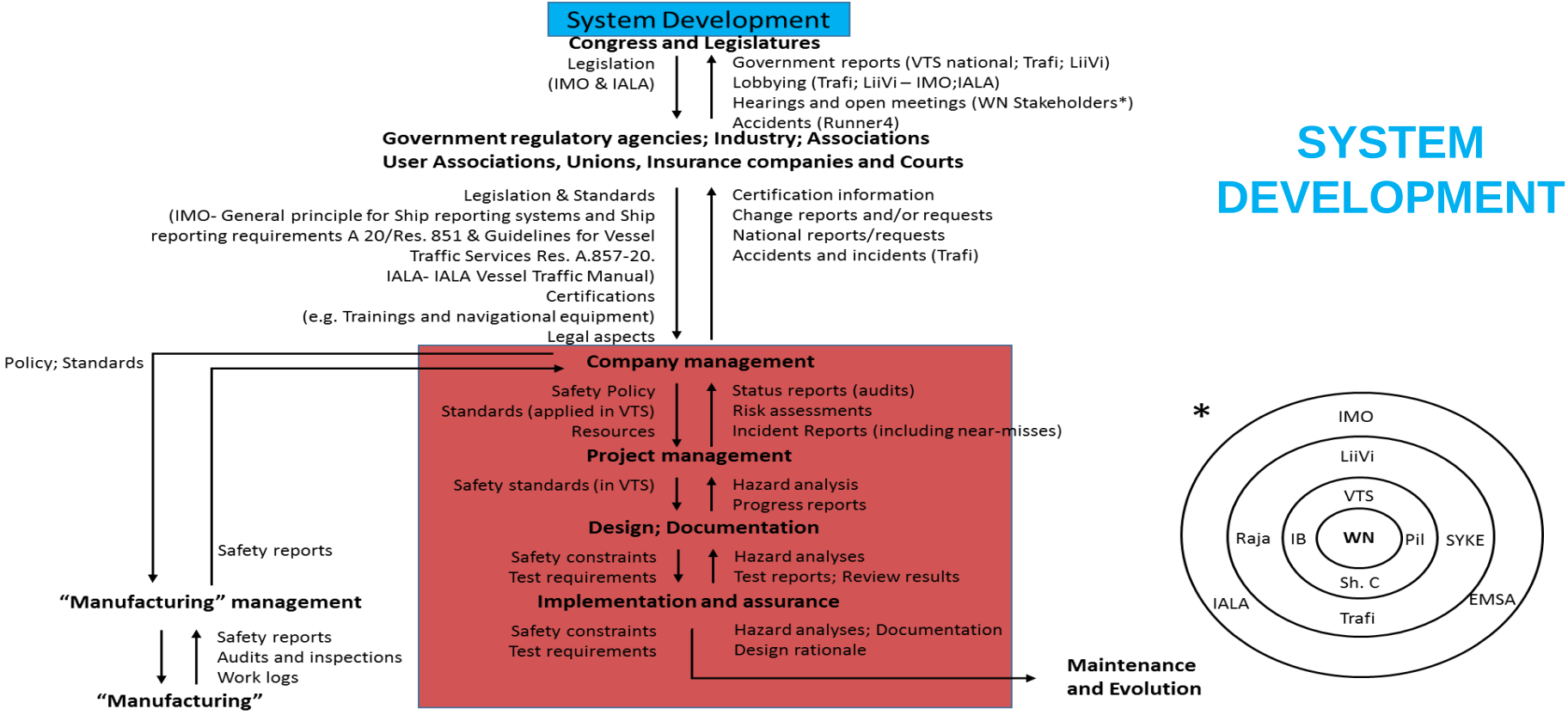
Aim

Create a **method for planning, reporting and analysing VTS safety management by using KPIs** which can proactively act against potential failures of the winter navigation safety system in VTS.

These KPIs are particularly focused in the **tasks performed in VTS during the sea ice season** in northern Baltic.

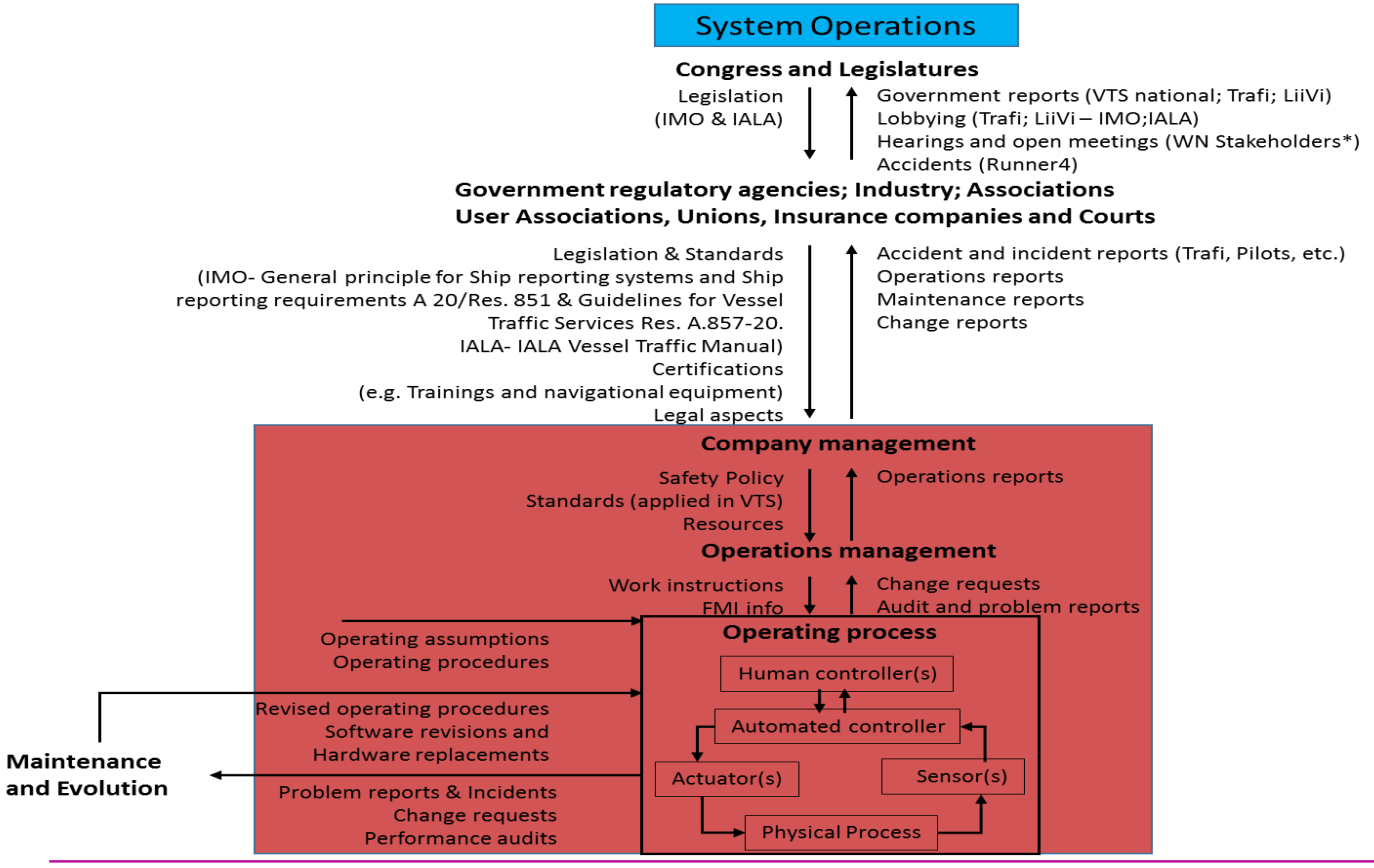
Method should serve as a basis for the **creation of a tool** which can the systemically assess the safety management of traffic control at VTS during the ice navigation season.

VTS model of sociotechnical control

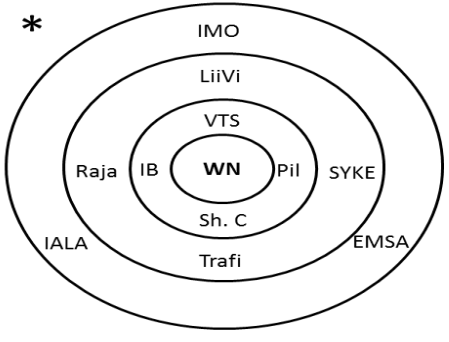


SYSTEM DEVELOPMENT

VTS model of sociotechnical control

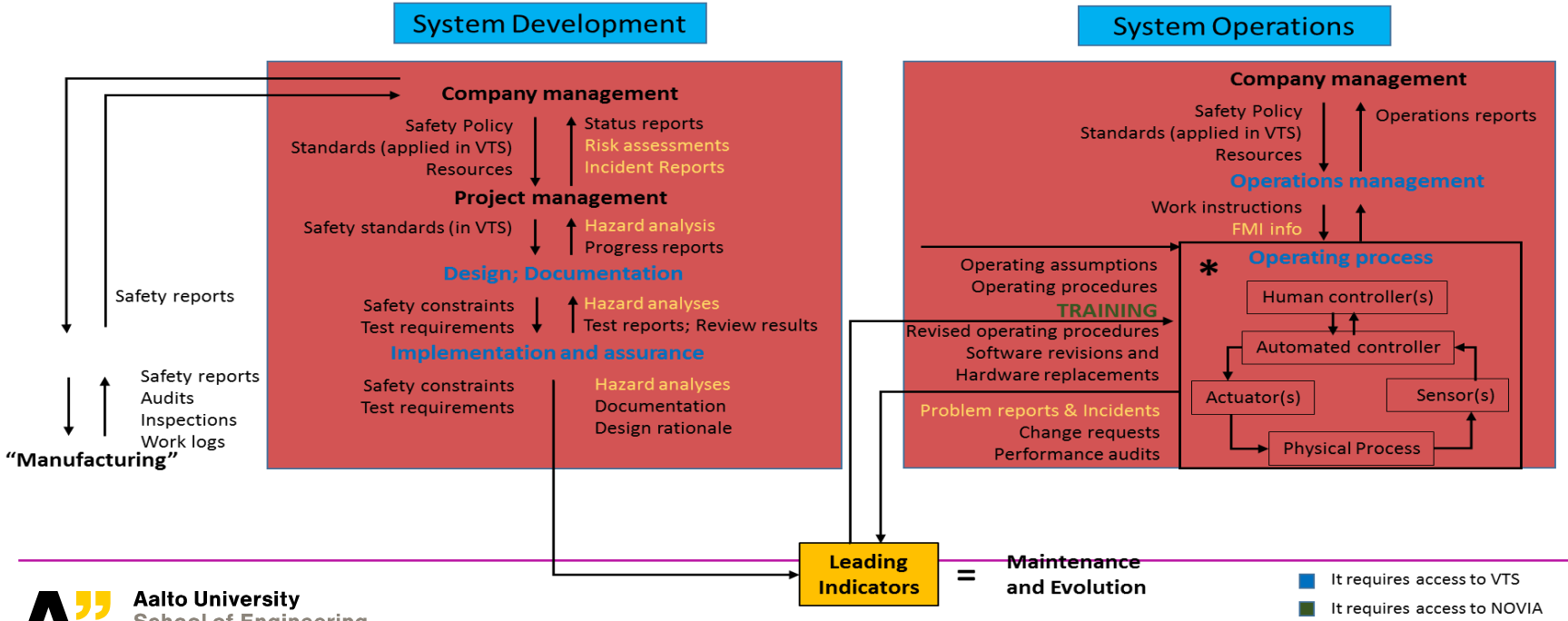


SYSTEM OPERATIONS

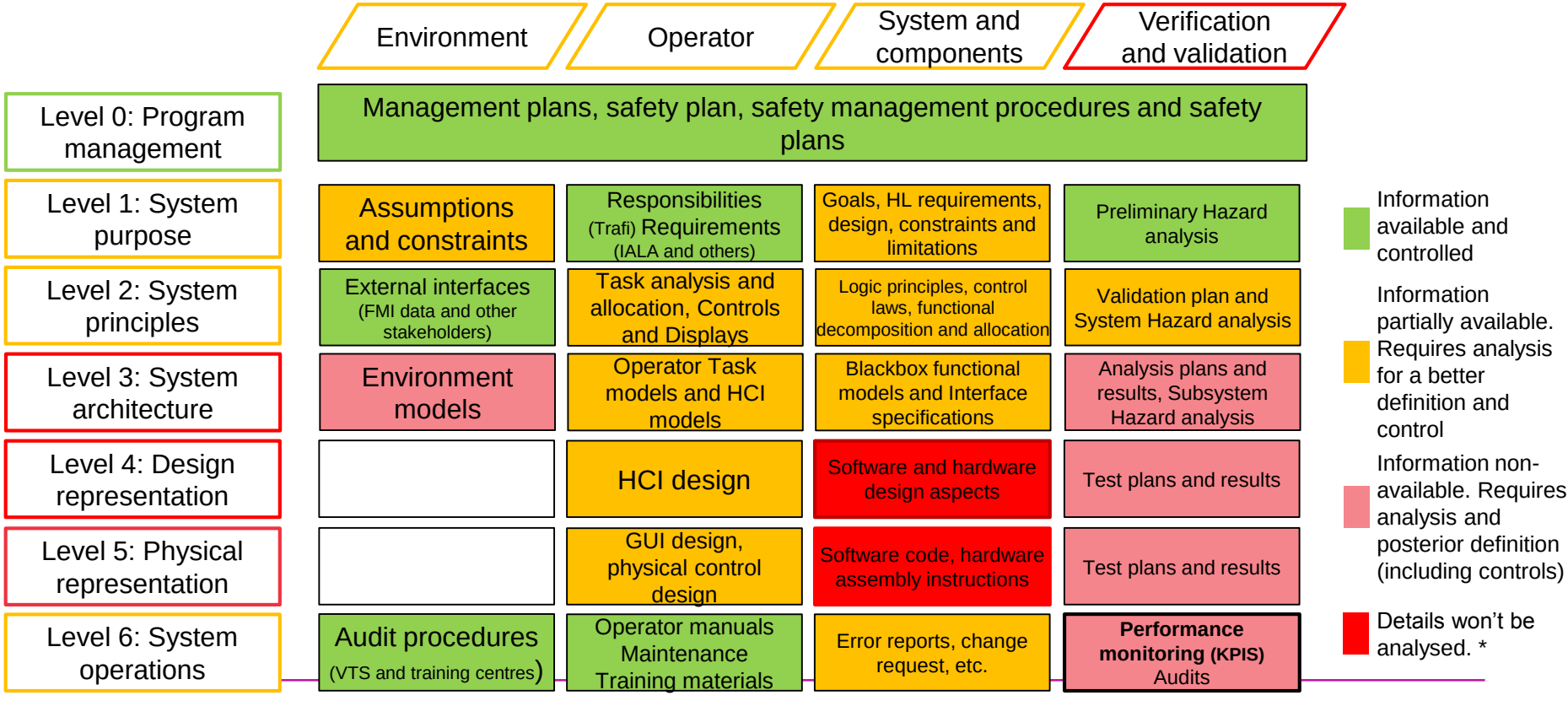


VTS model of sociotechnical control

STAMP is applied to systemically identify system hazards, controls and constraints in VTS system, by reviewing operational and training procedures and performing field visits to VTS centres and simulator training environments.



Defining the structure of the VTS intent specification



VTS Integrated System and Safety Engineering Process

Defining the Goals of the System

It has to be aligned to the VTS general operative aim: *Monitor, control and improve safety and efficiency of vessel traffic and protect the environment.*

Thus:

The planned study should result in a **new proposal for evaluating the safety management in VTS operation and training**, in order to specifically detect which areas may need further improvement in order to ensure and strength VTS aim.

VTS Integrated System and Safety Engineering Process

Define and categorized accidents

An undesired and unplanned event that results in a loss (including loss of human life or injury, property damage, environmental pollution, and so on).

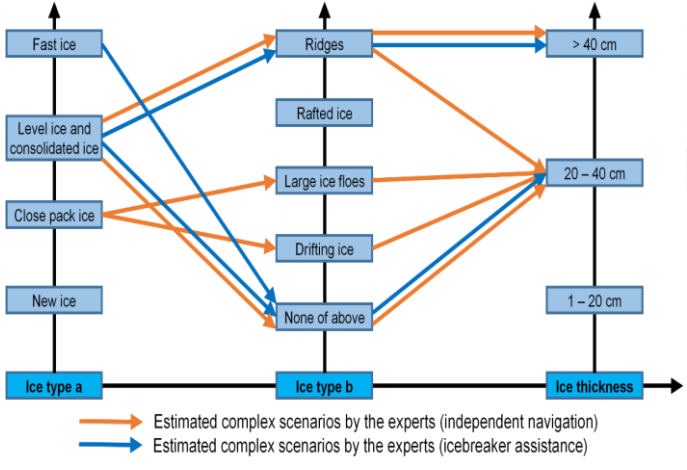
- **Very serious:** an accident that leads to human casualty and/or seriously exposes to it, and can also be associated with total loss or severe damage of vessels and the environment.
- **Serious:** an accident that has consequences that could lead to a major impact on human safety, vessel structural safety and the environment.
- **Less serious:** an accident that has a minor repercussion on human safety, minor damage to ship machinery and structure, and a non-significant impact on the environment.

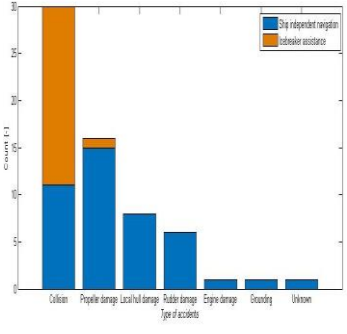
VTS Integrated System and Safety Engineering Process

Hazard identification

The main idea is to use the information of the recent hazard identification analysis performed, in order to later apply the two steps of the STPA.

Hazardous scenarios in winter navigation operations





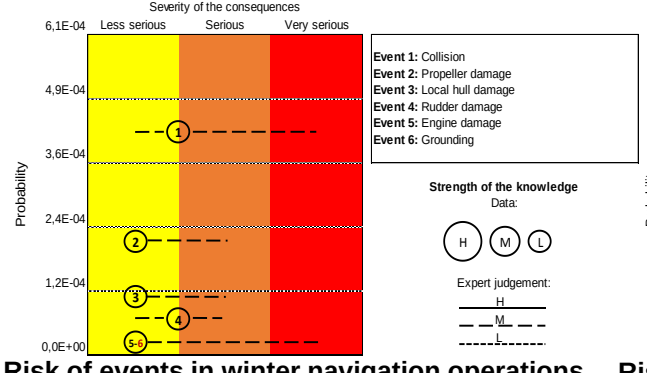
Scenario	Event	Contributing factors
Vessels navigating independently may have problems in navigating under difficult ice conditions	Ice compression and vessels stuck in ice	Environmental and ice conditions. Level ice, consolidated ice and fasted ice with an thickness between 15 and 40 cm
Drifting ice affecting the course of the ship	Collision and grounding	Environmental and ice conditions. Particularly, drifting ice due to current and winds during spring time.
Drifting ice which moves and/or creates pressure to a ship stuck in ice	Ice compression and vessels stuck in ice	Environmental and ice conditions. Drifting ice moving due to currents and winds, which creates pressure on ship's hull.
The overtaking of independently navigating vessels in an ice channel.	Collision	Operational mode. Manoeuvring the ship in a limited space
Ships navigating independently and encountering ice ridges.	Hull damage, propeller damage and ice compression	Environmental and ice conditions. The thickness of the ridges is higher than the ice thickness of the level ice, and those ridges may act as hidden barrier when ships are breaking the sea ice.
Formed ship convoys navigating in ice conditions.	Collision	Operational mode. The limited manoeuvring space and the high speeds commonly required for navigating under ice conditions possibly trigger accidents.
The independent navigation of large vessels (e.g. tankers, bulk carriers and containerships).	Grounding	Environmental and ice conditions. Particularly during spring time when the ice is thick and ice fields start to move affecting the course of the vessels
A vessel hitting large ice floes	Hull damages	Environmental and ice conditions. Large ice fields which break off from ice level and consolidated ice

VTS Integrated System and Safety Engineering Process

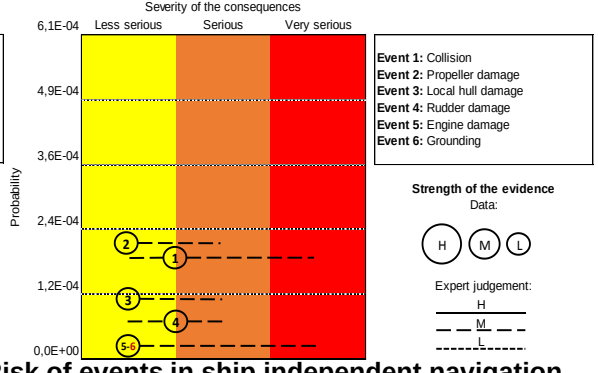
Architectural trade analysis and hazard analysis

The definition of the system concept formation has to be develop together with VTS representatives by presenting the results from the hazard analysis.

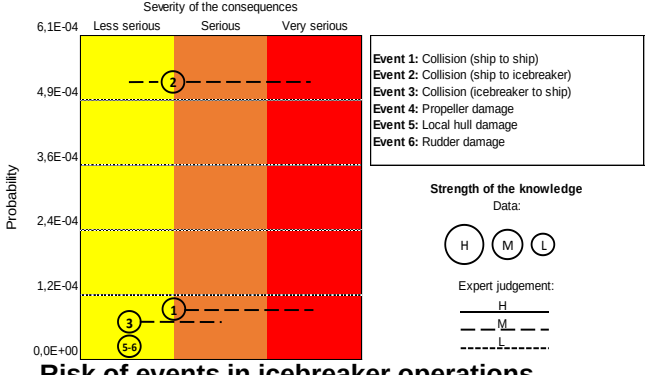
For the definition of risk in winter navigation, some work was already developed:



Risk of events in winter navigation operations



Risk of events in ship independent navigation



Risk of events in icebreaker operations

VTS Integrated System and Safety Engineering Process

Documenting environmental assumptions

Example: VTS ensures that communication with the monitored ships can be established at any moment.

The idea is to document the most relevant assumptions based on the analysis of the operations and identified hazards.

Generating the System-level requirements

This task have to accurately link the identified goals and hazards, and also the requirements demanded in e.g. IALA normative

VTS Integrated System and Safety Engineering Process

Identify H-L design and safety constraint

Following the example: VTS ensures that communication with the monitored ships can be established in any moment.

SC.1 VTS system must ensure the functionality and availability of the communication means

SC.1.1VTS system must test constantly the functionality of the communication means.

SC1.2 VTS system must ensure that programmed maintenance of the communication equipment is efficiently executed.

This complete process is guided by the development of the STPA hazard analysis. Thus, creating connection between hazards and identified risk.

VTS Integrated System and Safety Engineering Process

From System Design to "certification (validation), maintenance and evolution.

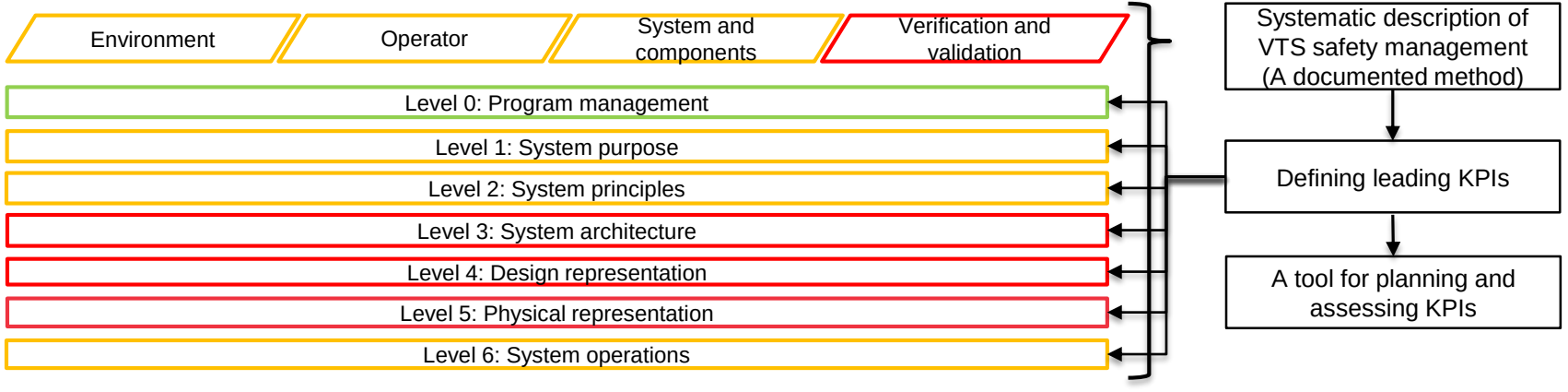
The analysis and elaboration of levels 2 to 6 will continue by following the guidance included in STAMP and STPA. These levels represent a challenge because it combines the analysis of:

- Roles and responsibilities within VTS
- The defined functional requirements and safety constraints, in order to assess their compliance with demanded regulatory requirements and need of the operations (VTS ops and WN ops)
- Implemented training. Including an evaluation of the training provider.
- Implemented technology for the development of the operations in VTS. Also, including an analysis of the technology provider (VTS monitoring system).
- The actual operations (e.g. icebreaker assistance operations).
- Previous audits and elaboration of new reviews.

Intended goals

The construction of method for a systemic analysis of safety management

The main purpose is to elaborate a documented method which systematically analyses the safety system in VTS. This method should describe the complete process of assessment of the safety management of traffic control during wintertime navigation.



The construction of method for a systemic analysis of safety management

Defining leading KPIs

This indicators have to be identified after the hazard analysis and the documentation created during development and analysis of operations are performed. Therefore, feedback loops are essential to detect these potential KPIs and also to posteriorly assess their adequate function.

Moreover, a new created method (5) for detecting and assessing the KPIs are going to be incorporated in the performance of this task. The characteristics of this method is linked to main purpose of STAMP.
Method uses Context-Mechanism-Outcome specifications to assign meaning and signifance to KPIs

5. Valdez Banda O.A., Hänninen M., Lappalainen J., Kujala P. and Goerlandt F. (2015) Submitted to Journal of Maritime Affairs (JOMA)

The construction of method for a systemic analysis of safety management

The systematic description of VTS safety management will be based on the application of the analyses previously introduced to “one” of VTS centre in Finland. The intention is to accurate describe and analyse the safety arrangements made for ensuring navigation in ice conditions

The intention of the KPIs is to assess all different levels of the structured VTS intent specification. Thus, providing early alarms to anticipate the system migration towards higher risk.

Finally, a tool for planning and assessing the KPIs will be elaborated. The intention is to provide an actual instrument which allows the monitoring and assessment of VTS safety management.

Limitations and concerns

General limitations and concerns

- VTS centres are not 100% similar in the way they operate. The arrangements for controlling and monitoring are organized depending on the demands on the controlled area. This affects the organizational management and structure, implemented technology and modes of operation.

- VTS has limitations in the traffic controlling. Any VTS is a hub of information and this information is commonly shared with different stakeholders. However, VTS in practice can only provide guidance and recommendations, the final execution of any operation is decided by e.g. masters and crew.

- The management of safety during ship navigation in ice conditions is a relative new area of research. Therefore, there is a lack of safety management guidance focused in the demands of ship navigation in ice conditions.

General limitations and concerns

- One of the general limitations in the maritime industry is the commonly poor quality of the incidents and accident description (particularly incidents and near misses). This is also the case of winter navigation. Moreover, accidents of ships in ice conditions are somehow scarce and the available information in the accident description is commonly very limited.

- STAMP encourages the analysis of the applied technology for safety purposes. This can be a challenge in the particular case of VTS because availability of detailed information is not common.

- STAMP provides guidance to go deeper in the analysis of safety. Thus, how to deal with an industry where safety in commonly controlled to the minimum requirements, bureaucracy is a constant in the development of safety management, and many valuable information remain unknown on the sea.

Acknowledgements

Acknowledgements

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Thank you