Proactive safety management in maritime traffic

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Introduction

Maritime accidents are low-probability, however high-consequence events which may have a devastating effect on the natural environment.


Oil spills mapped

Cause of oil spill
🐎 Blowout   🚢 Tanker

6 Amoco Cadiz
7 Haven
8 Odyssey
9 Torrey Canyon
10 Sea Star
Exxon Valdez
Deepwater Horizon
1 Ixtoc 1
2 Atlantic Empress
3 Nowruz Oil Field
4 ABT Summer
5 Castillo de Bellver

http://news.bbc.co.uk/2/hi/uk_news/magazine/8664684.stm

MICROSOFT

Exxon Valdez 1989		37,000
TOP 10 Sea Star 1972		115,000
Torrey Canyon 1967		119,000
Odyssey 1988		132,000
Haven 1991		144,000
Amoco Cadiz 1978		223,000
Castillo de Bellver 1983		252,000
ABT Summer 1991		260,000
Nowruz Oil Field 1983		272,000
Atlantic Empress 1979		287,000
Ixtoc 1 1979		476,000

Source: ITOPF, Oil Spill Intelligence Report
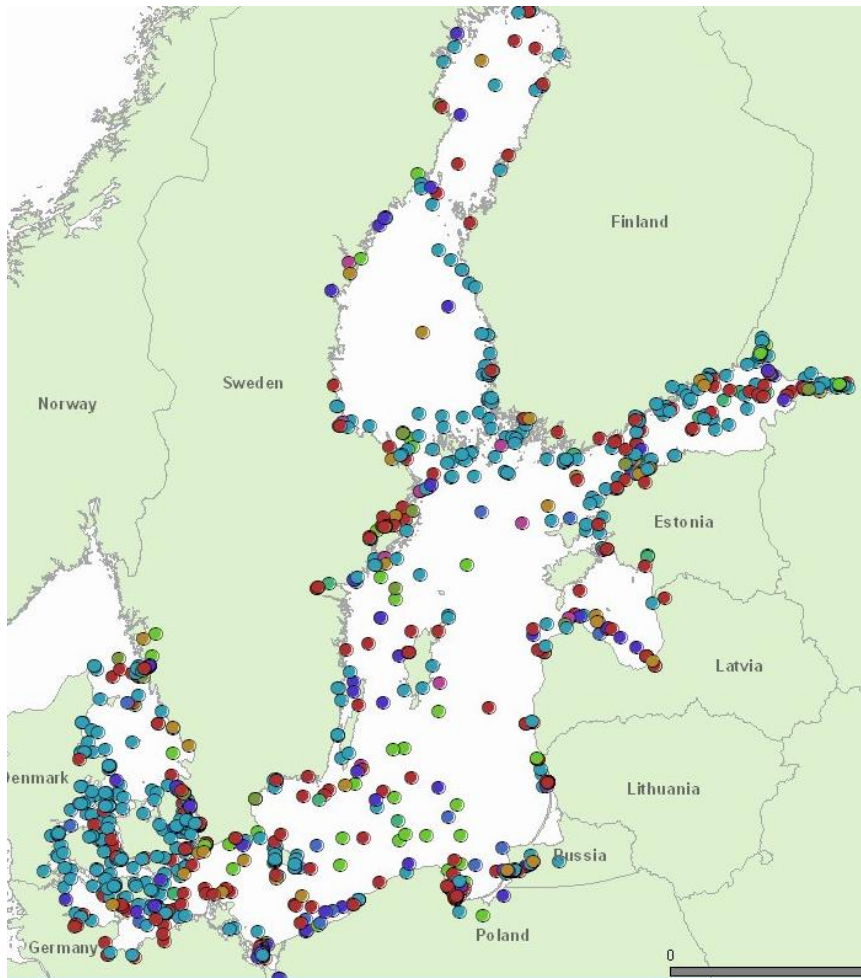
Tanker Casualties, Historical data

■ Collision ■ Contact ■ Grounding ■ Fire ■ Explosion ■ NASF
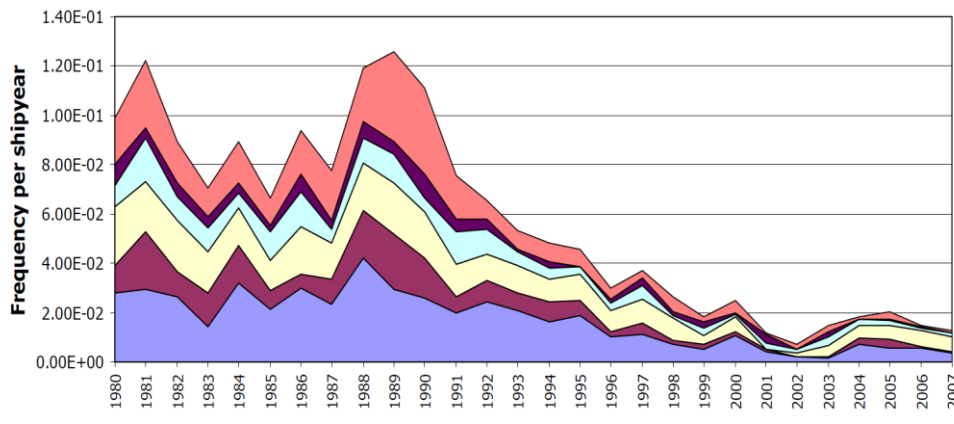
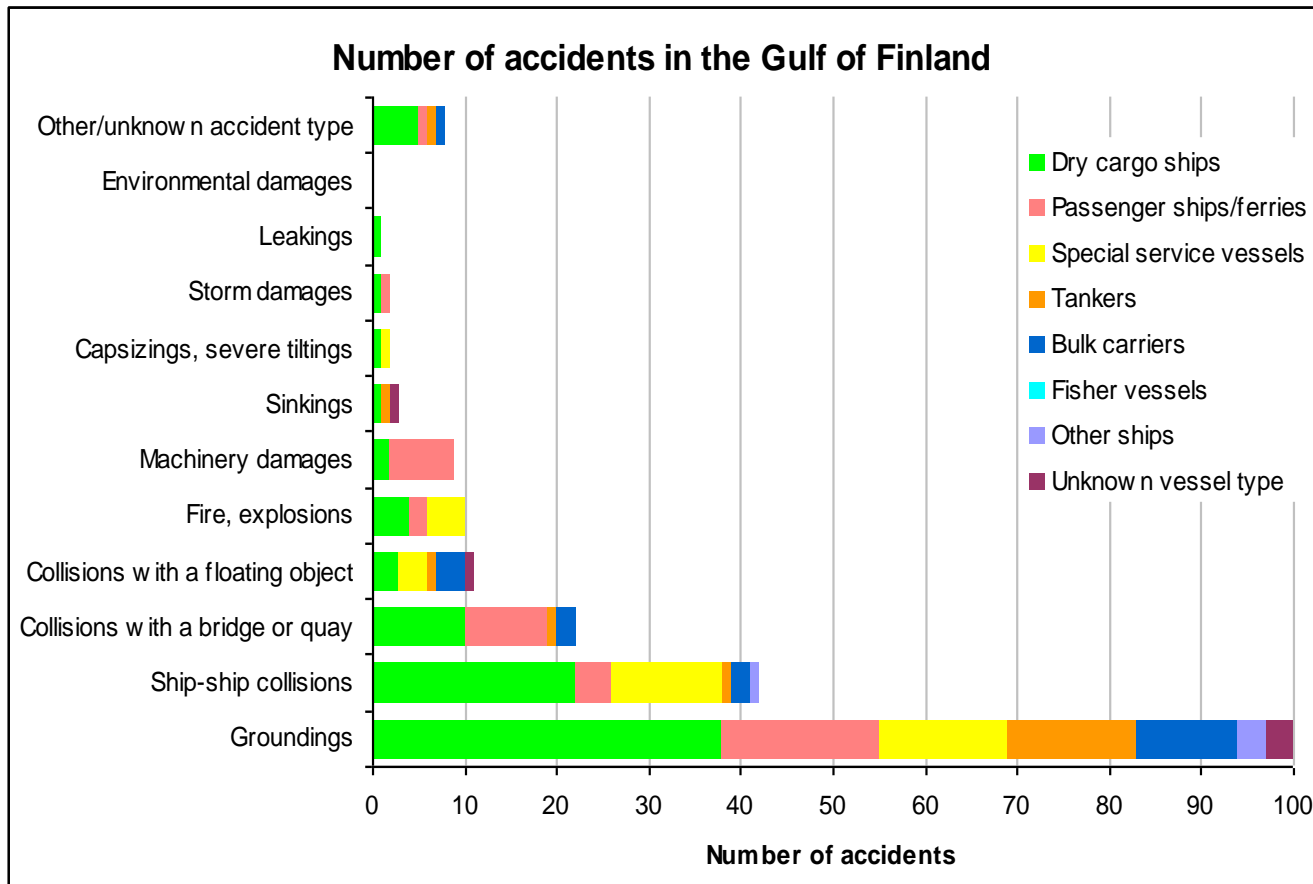Annual fluctuation of incident frequencies per ship-year (adopted from MEPC 58/INF.2)

Introduction
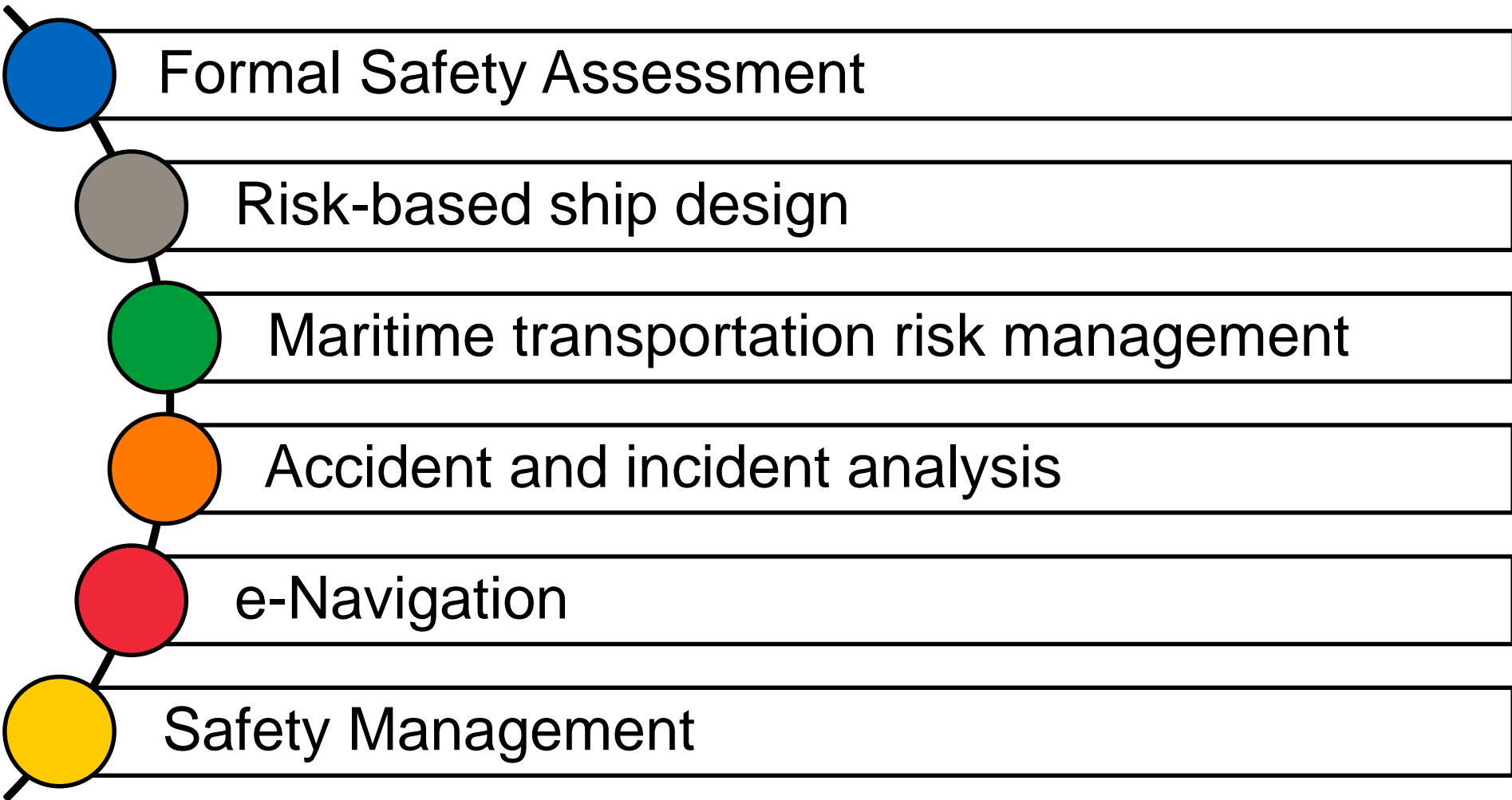

ACCIDENTS IN THE BALTIC SEA 1989-2008

Source:
http://maps.helcom.fi/website/MARIS/viewer.htm

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Introduction

ACCIDENTS IN THE GULF OF FINLAND 1989-2008

Main research topics

- Formal Safety Assessment
- Risk-based ship design
- Maritime transportation risk management
- Accident and incident analysis
- e-Navigation
- Safety Management

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Formal Safety Assessment
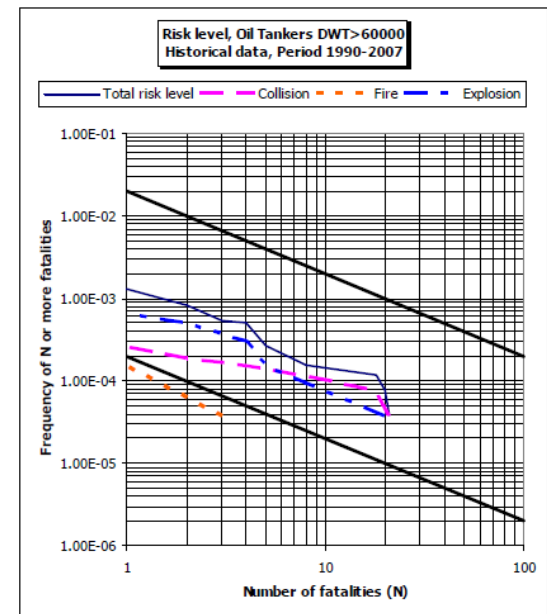## A starting point for maritime risk

- Conceived as a proactive, rather than reactive tool to make decisions regarding **regulations at IMO level**

- First applied to assess the need for **ship design** changes and carrying of new **safety equipment**

- Later also used as a tool for decision making in other contexts:
  - Navigational risk
  - Implementation of routeing schemes (TSS)
  - Operational risk

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Formal Safety Assessment
State of art in Research

- Results of FSA studies
  - Container vessels
  - Cruise vessels
  - RoPax vessels
  - LNG carriers
  - …

- Critical reflections on concepts, methods and process
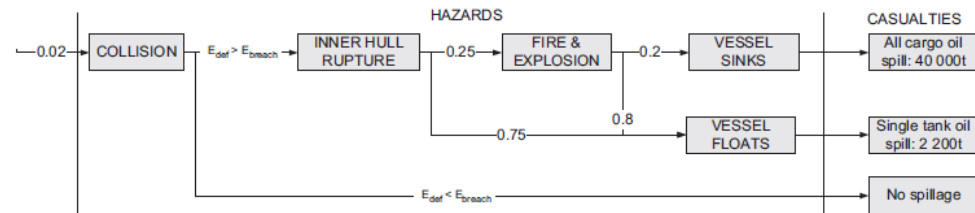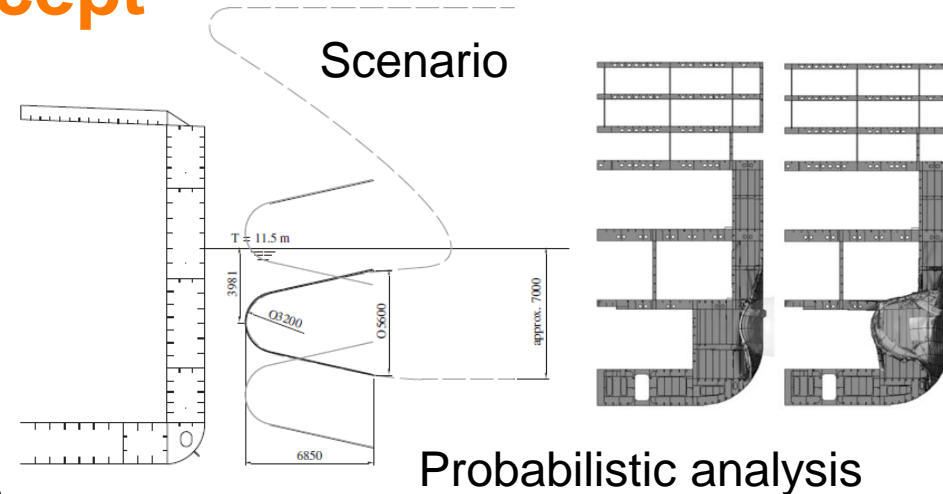
- Reviews and accounts of expert group meetings

Societal risk level
ALARP

Wang J. 2001. Safety Science.
Psaraftis H. 2012. Journal of Marine Science and Technology.
Montewka et al. 2014. Reliability Engineering and System Safety.
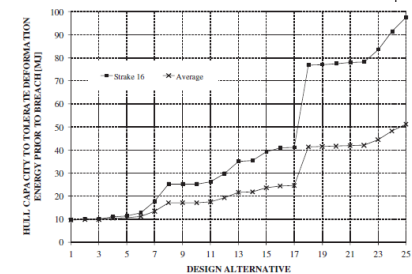
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Risk-based ship design
Concept

- **Traditional ship design** relies extensively on prescriptive rules
  - Little flexibility
  - Possibly sub-optimal designs

- **Risk-based ship design**
  - Incorporates risk analysis in the ship design process
  - Risk is a design objective
  - Often in combination with optimization techniques

Scenario

Probabilistic analysis

Optimization

Klanac and Varsta. 2011. Reliability Engineering and System Safety
Ehlers and Tabri. 2012. Marine Structures.

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Risk-based ship design
State of the art in research

Collision - stability

- Probabilistic damage stability regulations
    - Revised SOLAS part B-1
    - A (attained subdivision index) ≥ R (required)
- Risk analysis methods applied to:
    - Collision and grounding damage
    - Flooding and stability in waves
    - Fire and fireproof compartimentation
    - Influence of noise, vibration, motion on human error in collision and grounding
- Tools exist, but many open issues
    - Influence of local design on existing methods
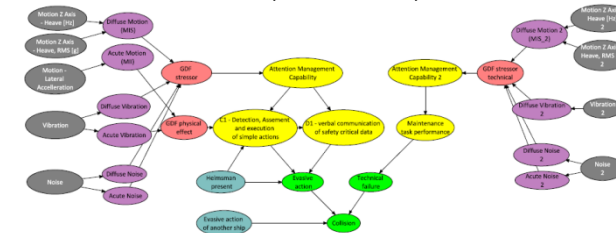   - Cross-validation across methods
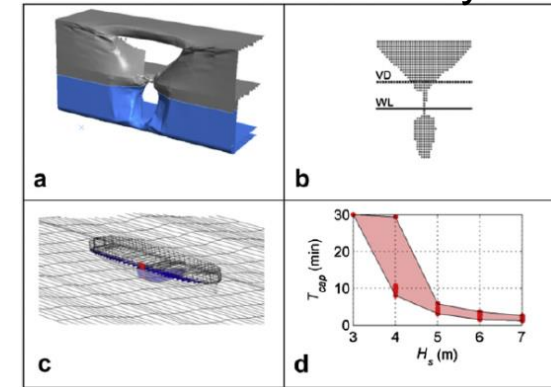
Fire - compartimentation
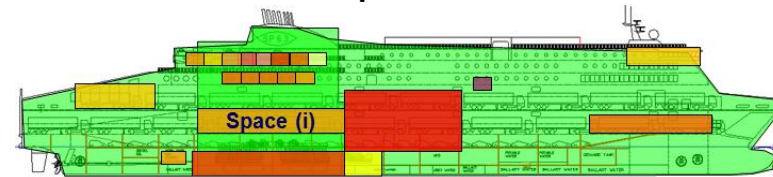
Vibration, noise, motion

Hogstrom and Ringsberg. 2012. Marine Structures.
Puisa. 2013. FAROS workshop
Montewka et al. 2014. PSAM conference

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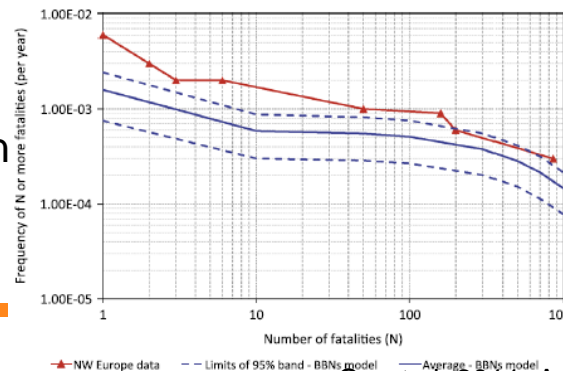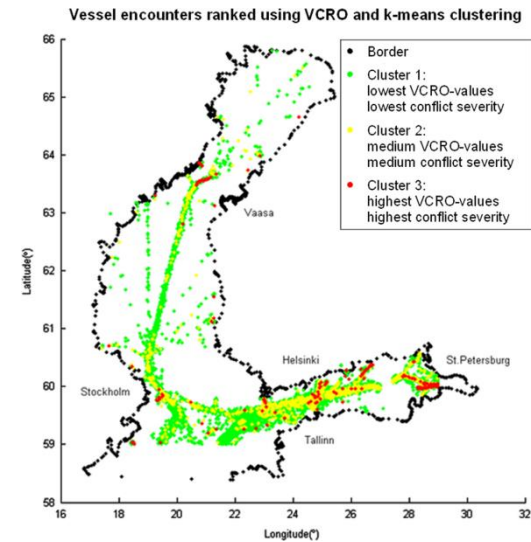# Maritime transportation risk management
Concept

- Assess risk of maritime transportation in a sea area
- Aims
  - Identify high risk areas
  - Indentify importance of contributing factors
  - Evaluate effect of modifications to traffic schemes
  - Evaluate need of RCOs and effect of implementation
- A number of frameworks on how to address the problem
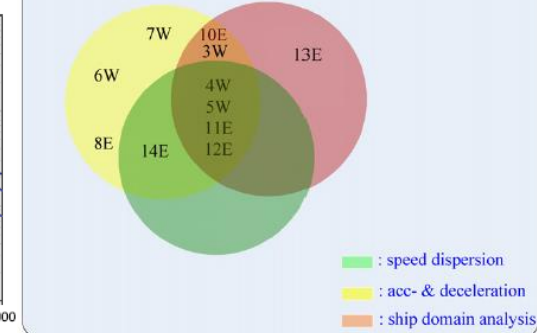 - Traffic flow, simulation, Bayesian Networks, Near-miss analysis

Accident probability

Encounters analysis

Risk indicators

BRISK Project report. 2011.
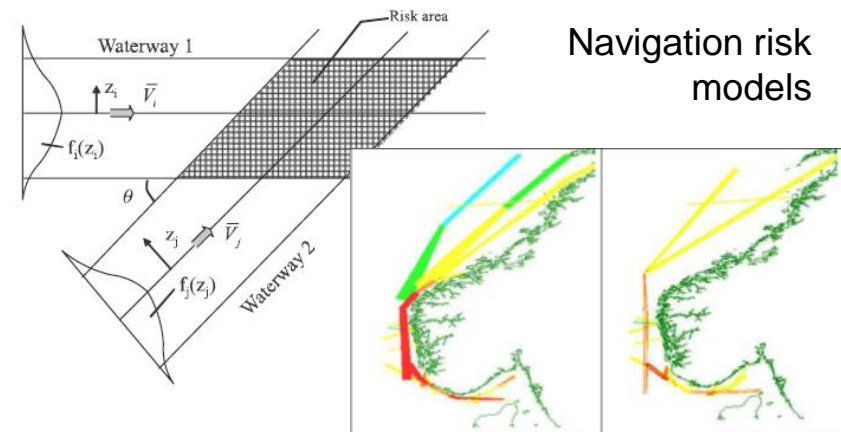Qu et al. 2011. Accident Analysis and Prevention
Montewka et al. 2014. Reliability Engineering and System Safety.
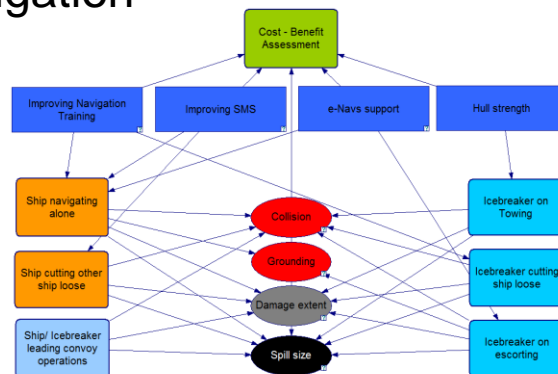Zhang et al. 2015 Ocean Engineering

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Maritime transportation risk management
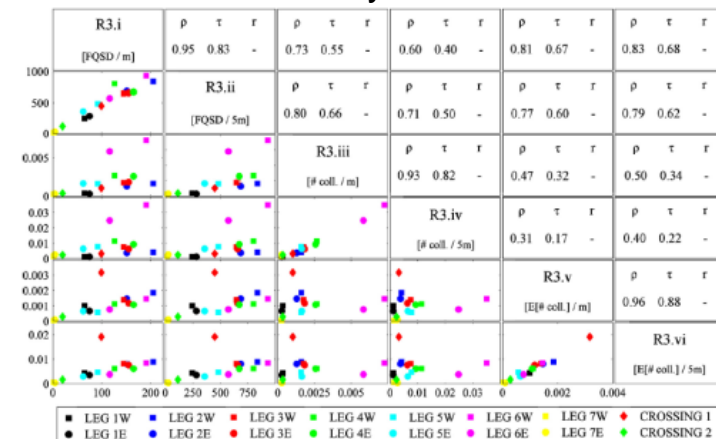## State of the art in research

- Various methods
  - Collision, grounding, fire, sinking,…
  - Often data-driven
  - Little attention to human error
- Open / ongoing issues:
  - Reliability and validity
 - Risk management for winter navigation

Navigation risk models

RMM winter navigation

Reliability tests for risk models

Otto et al. 2002. Marine Structures.
Akhtar et al. 2012. WMU Journal of Maritime Affairs.
Goerlandt and Kujala. 2014. Safety Science.
Hänninen et al. 2014. Proc. Mech. Eng. Part O
Valdez-Banda et al. 2014. WINOIL Seminar

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Maritime transportation risk management
An example from own yard

Risk analysis for winter winter navigation in the Baltic Sea
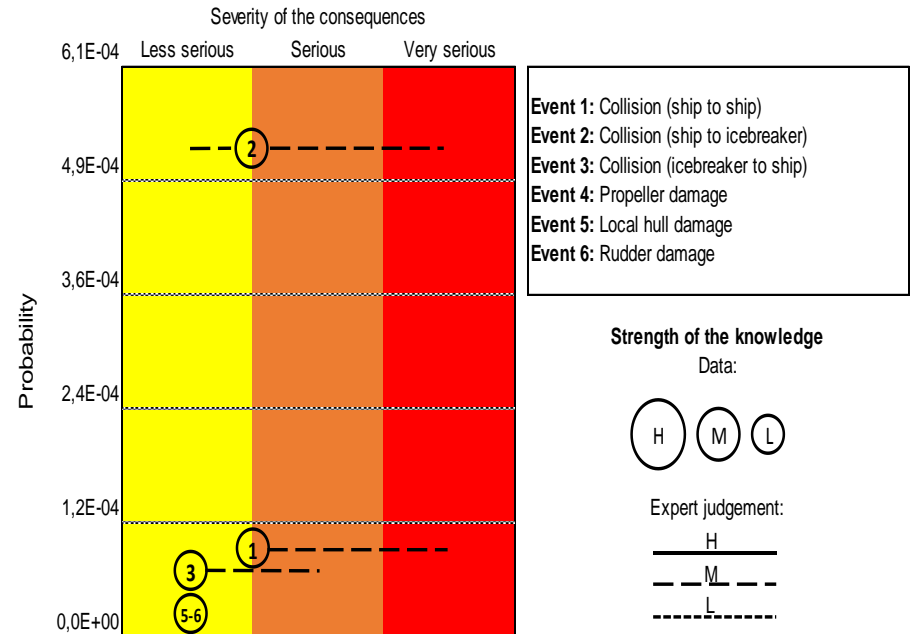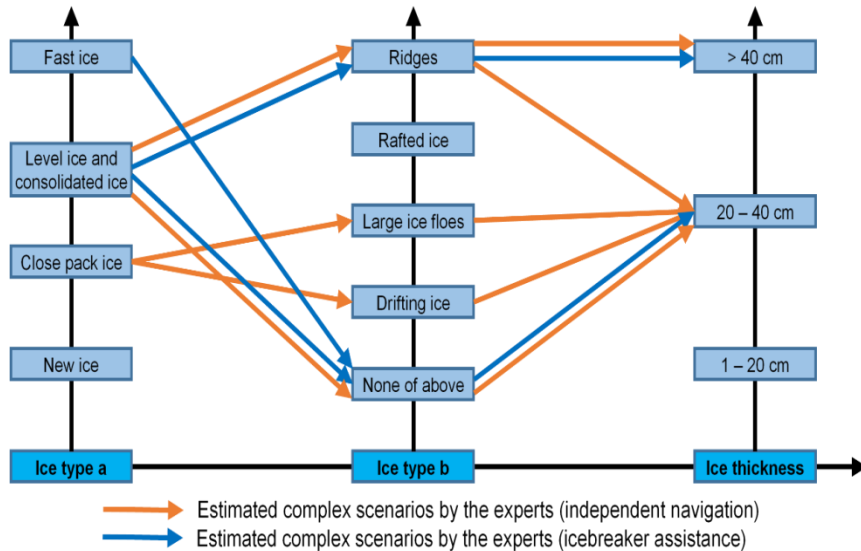
Valdez-Banda et al. 2015, Accident Analysis and Prevention

Accident / incident analysis
Concept

- **Global analysis** of accident and incident data
  - Statistical analyses
  - Trends
  - Relations between parameters under which events occurred
  - Constrained by data availability and what data is recorded

- Analyses of **specific accidents**
  - Understanding specific failure mechanisms
  - Insight of factors affecting incident occurrence
  - Can lead to proposals for corrective action
  - Constrained by the method used to analyse accident

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Accident / incident analysis
State of the art in research

- Methodological frameworks
  - Grounded theory, HFACS, CAST
  - Machine learning techniques
  - Visual data mining
- Discussions on:
  - Reliability / deficiencies of methods
  - Studies on underreporting
- Mainly global data analyses
  - Global statistics and specific geographical areas
  - Accident trends for ship types
  - Influence of environmental factors
- Relatively underdeveloped

Statistical analysis
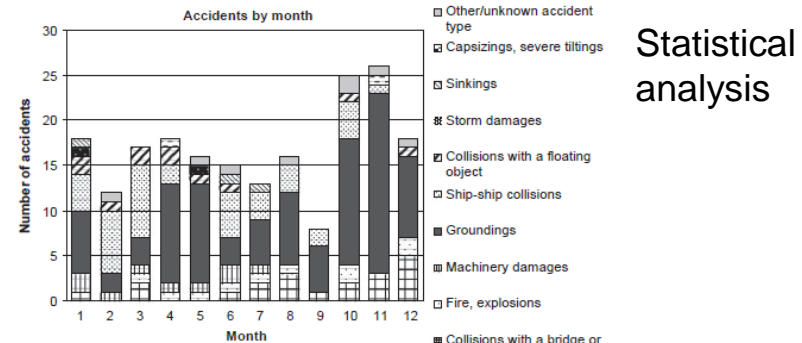
Machine learning of inspections and accidents
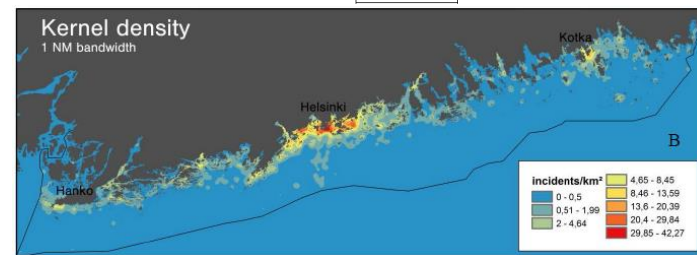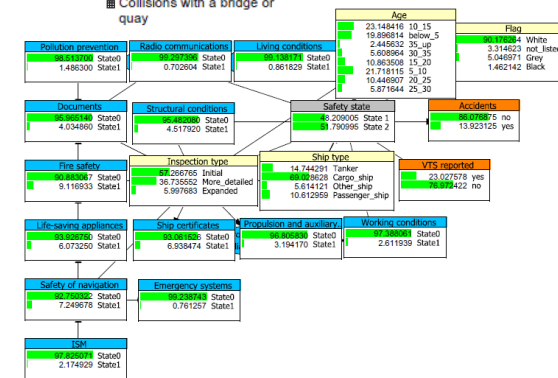
Data mining of boating incidents

Kujala et al. 2009. Reliabiilty Engineering and System Safety.
Hänninen et al. 2014. Expert Systems with Applications.
Goerlandt et al. 2015, Scientific Journals of the Maritime University of Szczecin

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Accident / incident analysis
State of the art in research

Evidence-based, probabilistic risk model for ship grounding accident

Mazaheri et al. 2015, Safety Science
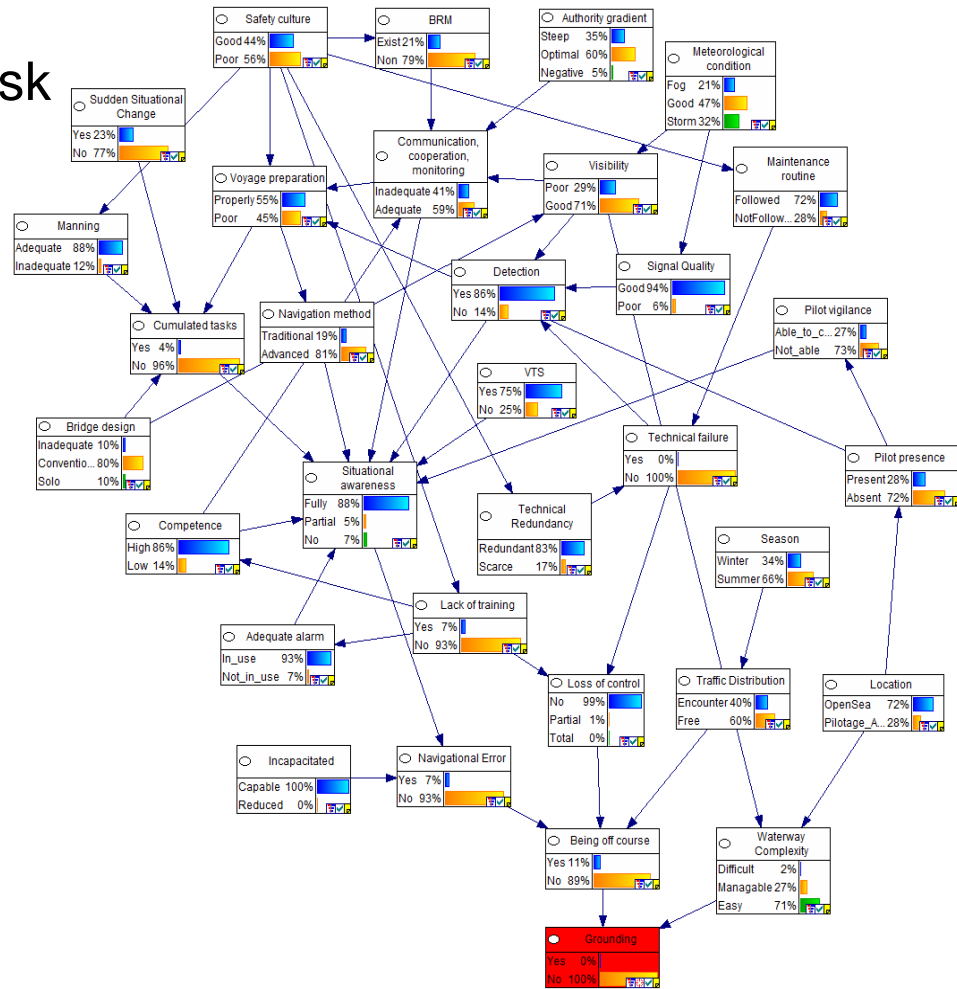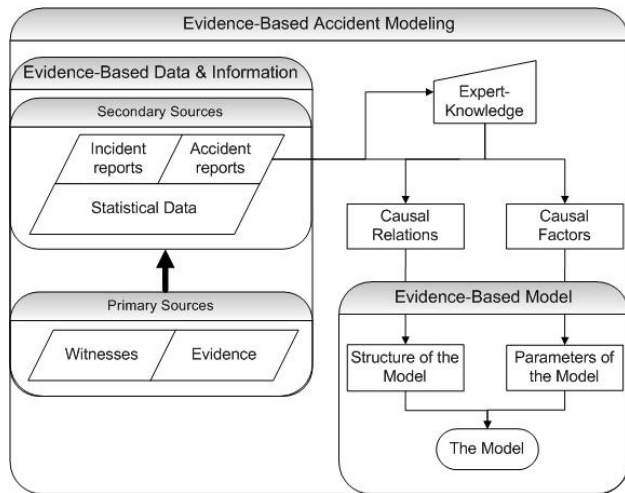
e-Navigation
concept

- The harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment

- Platform for developing tools to support decision making for safety and environmental protection
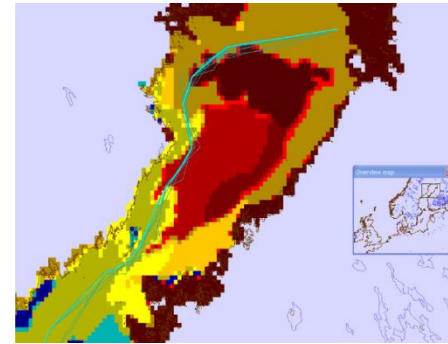
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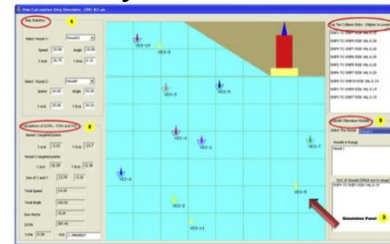
e-Navigation
state of the art in research

Route optimization

Dynamic risk

On-board support

CAS system

Communicating routes

Algorithms

- Ship routing
  - Optimization of routes in waves account for speed, accelerations, slamming,…
  - Optimization of routes in ice presently only speed

- Dynamic risk
  - Route exchange
  - VTS collision avoidance system
  - On-board maneuvering support
  - Ship risk factors
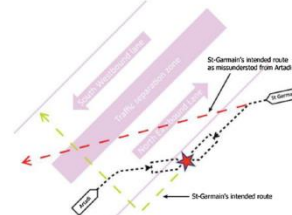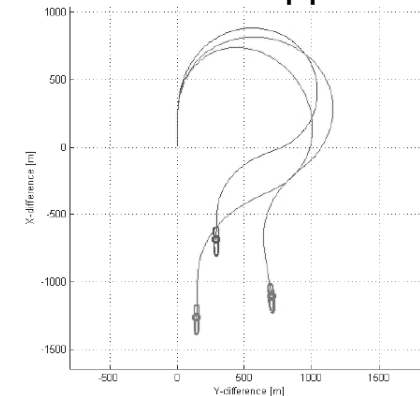 - Algorithms and test-beds
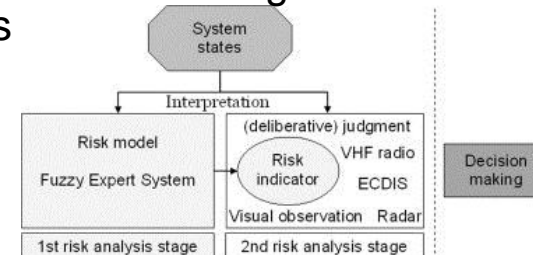
Kotovirta et al. 2009. Cold Regions Science and Technology.
Bukhari et al. 2013. Expert Systems with Applications.
Porathe et al. 2014. Accident Analysis and Prevention.
Balmat et al. 2009. Ocean Engineering.
Baldauf et al. 2011. TransNav
Goerlandt et al. 2015. Safety Science

e-Navigation
state of the art in research

ESABALT project

A common platform for crowdsourced information exchange to enable cooperation for enhanced maritime safety in the Baltic Sea.
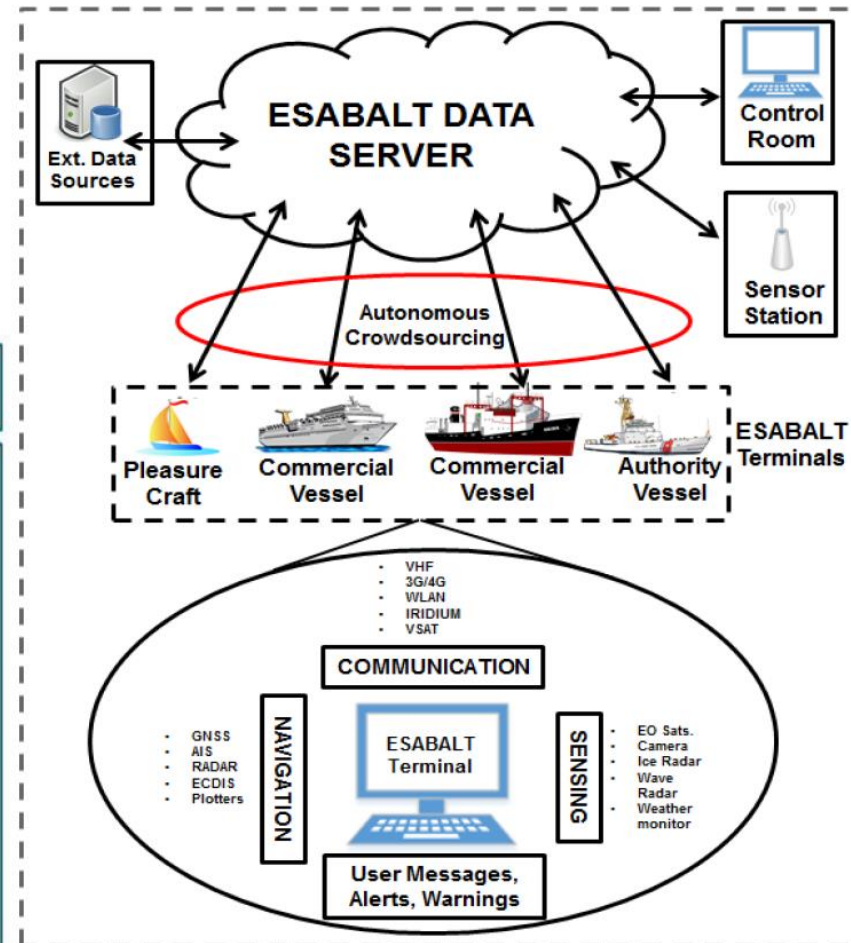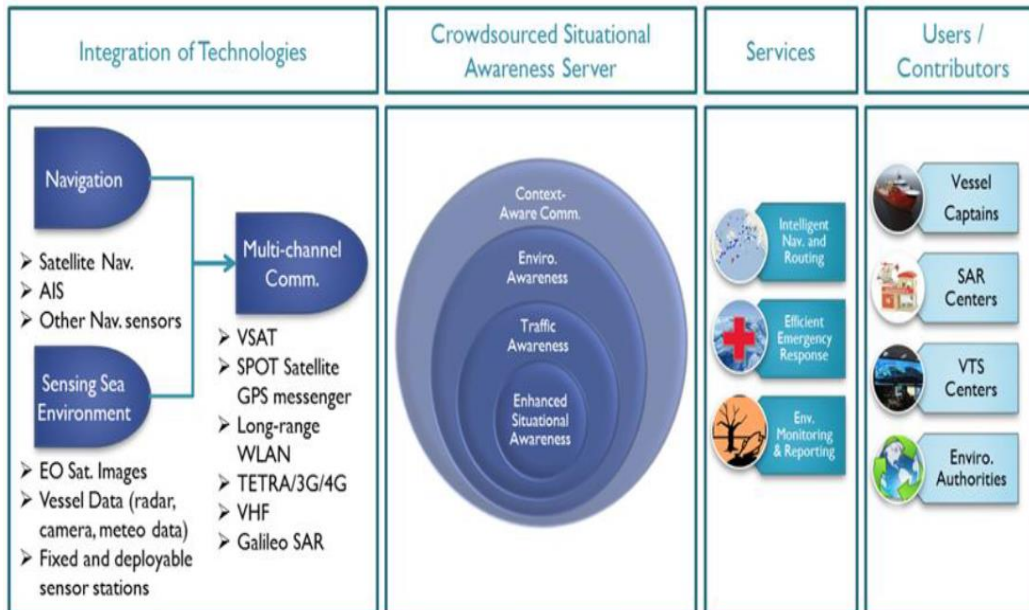
Thombre et al. 2015. TRANSNAV conference

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Safety Management
concept

- Safety management systems are used to monitor and assess the safety performance of a system

- Used as a basis for:
  - Documenting rule compliance
  - Decision making for safety investments
  - Continuous improvement

- Relatively recently implemented in the maritime industry through ISM code
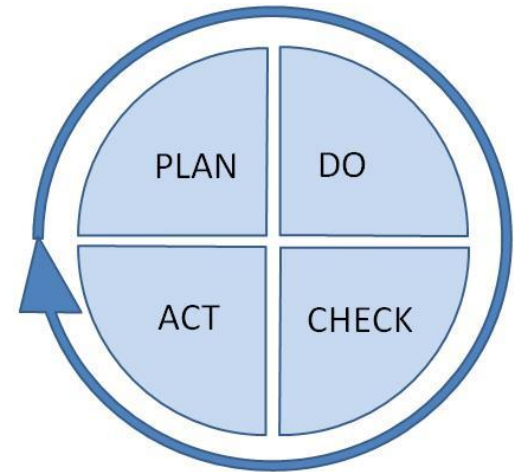
Safety Management
state of the art in research

- Relatively new issue in maritime safety research
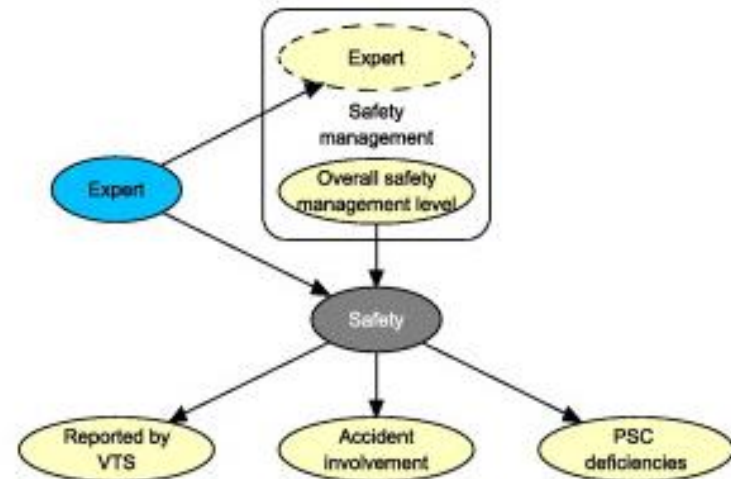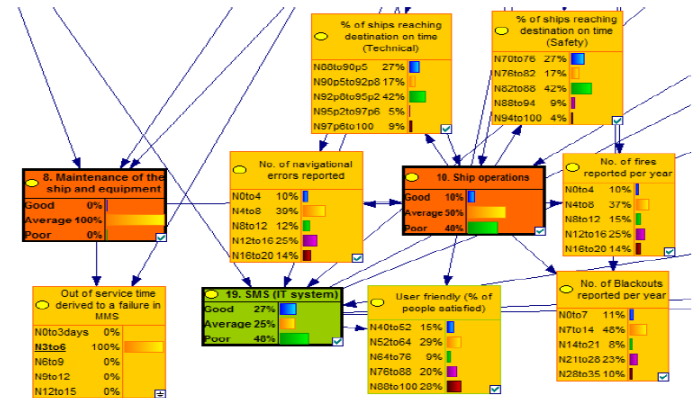
- Leading indicators programme

- Bayesian Network model for assessing safety performance

  - Current utility is mainly for:

    - providing an integrated system assessment
    - Exploring dependencies with accidents

  - Outlook for proactive decision support tools

- Much room for research on maritime safety management

Valdez Banda et al. 2014. PSAM conference.
Hänninen et al. 2014. Expert Systems with Applications.

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Discussion

- Trends in the shipping industry and regulatory bodies for exploring the possibilities of various tools in improving maritime safety are reflected in the research fields

- Relatively large focus on engineering and technical solutions and mathematical analyses

- There are gaps between science and practice

Discussion

- Research on maritime risk and safety is quite scattered

- Few schools specifically focus on this, mainly isolated individuals or ad-hoc cooperations

- Comparatively much focus on ship design and technical engineering solutions

- Potential of operational risk and safety management, accident analysis could be further explored

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Discussion

- There is a lack of conferences/workshops where practitioners from specifically the maritime safety research community can meet and discuss their work

- Specific research areas have a history in conferences
  - Ship design: IMDC and ICCGS
  - Maritime navigation: TransNav, MTE, IMAM

- A number of very general conferences about risk and safety exist
  - ESREL, PSAM, ICVRAM-ISUMA
  - Typically only minor role for maritime safety research

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IWNTM 2015

4th International Workshop on Nautical Traffic Models

26-29 August 2015, Espoo, Finland

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Research Group on Maritime Risk and Safety

Aalto University School of Engineering

The International Workshop on Nautical Traffic Models aims to establish a venue where the international research community can meet, present and discuss advances in following topics:

- modeling and simulation of maritime transportation flows on different geographical scales

- risk assessment and management for maritime transportation (environmental and societal)

- design and evaluation of countermeasures to enhance the safety of maritime transport

- accident analysis in maritime operations

Proactive safety management in maritime traffic

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