



Aalto University
School of Engineering



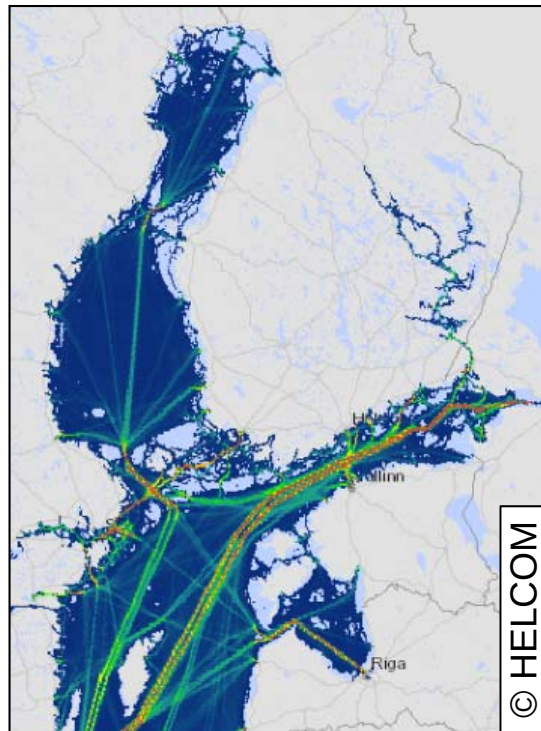
Strategic and Operational Risk Management for Wintertime Maritime Transportation System

Floris Goerlandt, Osiris Valdez Banda and Pentti Kujala

*Aalto University
Research Group on Maritime Risk and Safety*

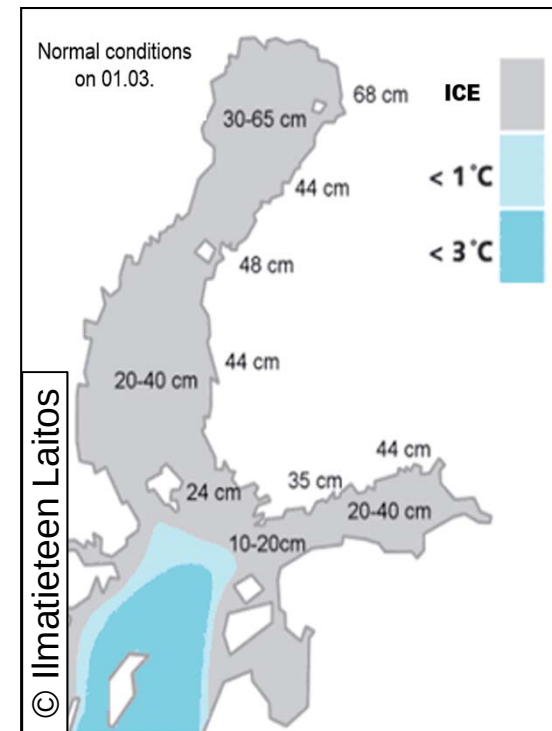
Context

Wintertime maritime transportation context



**Maritime
traffic**

**Sea
ice**



Wintertime maritime transportation risks



© TraFi

Wintertime operations



© H. Heikura, HS

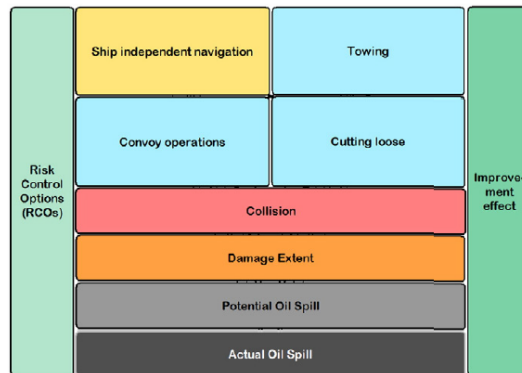
Oil spill in ice

STORMWINDS

Strategic and Operational Risk Management

STRATEGIC RISK MANAGEMENT

OIL SPILL RISK MANAGEMENT AND RESPONSE

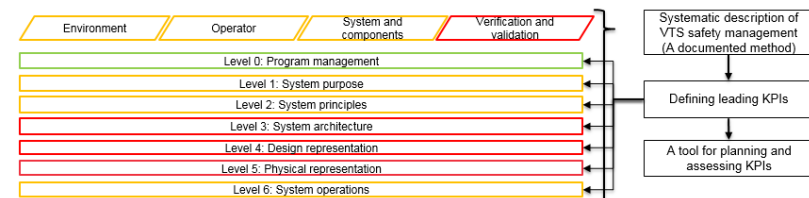
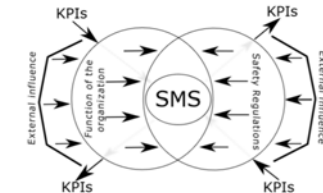


IMO 2010 Oil spill risk management model

SAFETY MANAGEMENT SYSTEM (SMS) OF VESSEL TRAFFIC SERVICES



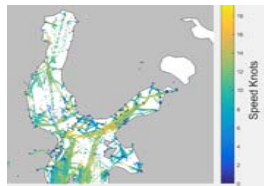
Vessel Traffic Services



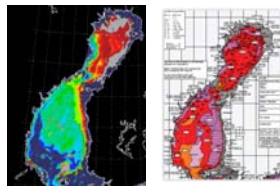
Safety engineering based SMS

OPERATIONAL RISK MANAGEMENT

E-NAVIGATION TOOLS FOR IMPROVED ROUTE PLANNING



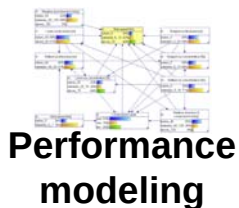
AIS data



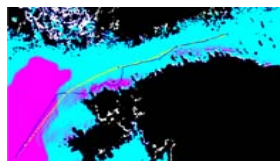
Ice charts



Performance
analysis



Performance
modeling

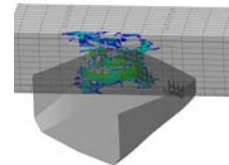


Route planning



Operations

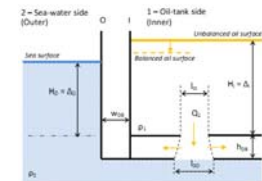
TOOLS FOR OPERATIONAL OIL SPILL RESPONSE



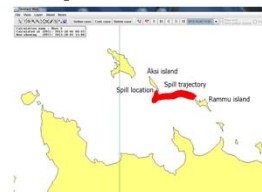
Accidental damage



Web-based tool



Oil spill evaluation



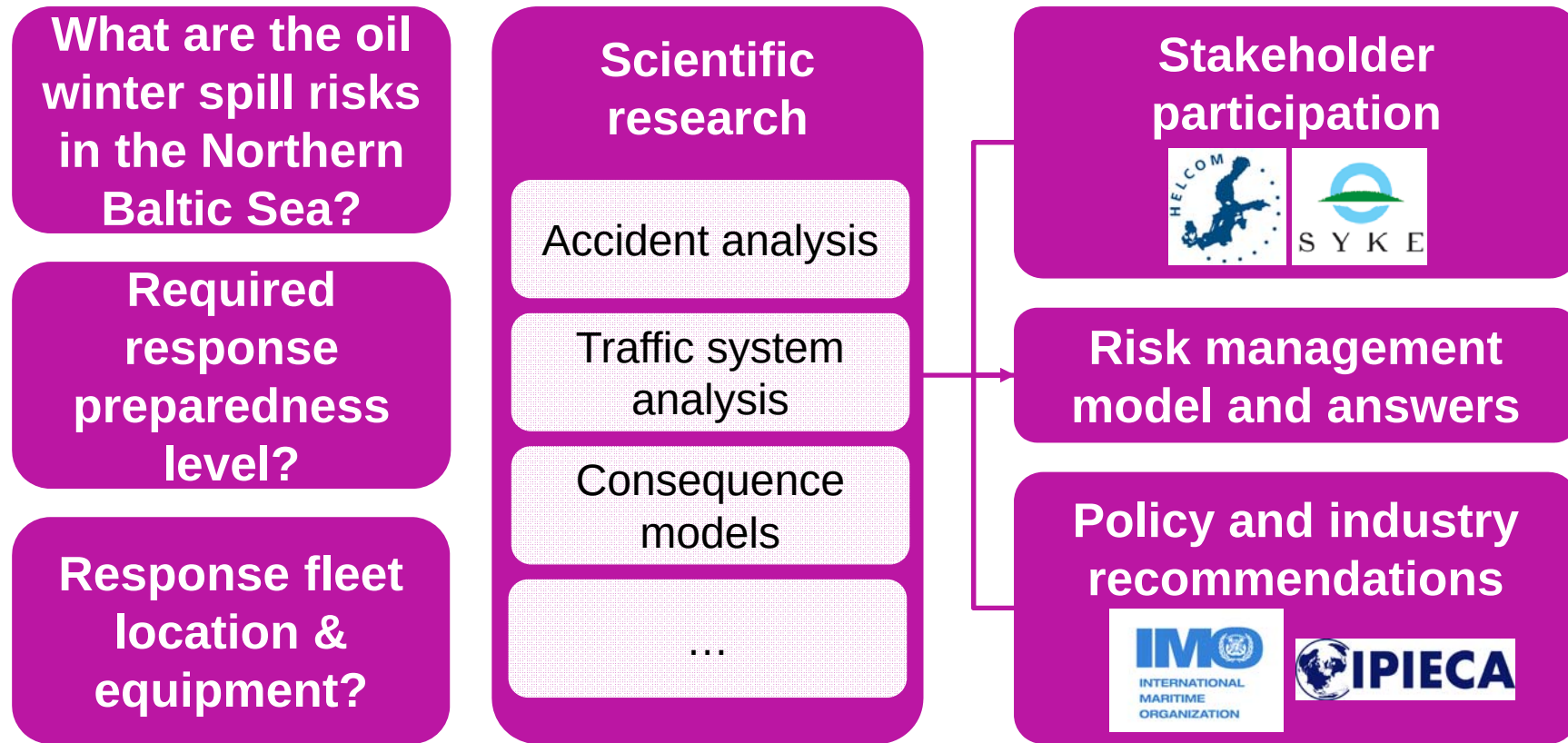
Oil spill propagation

Strategic oil spill risk management

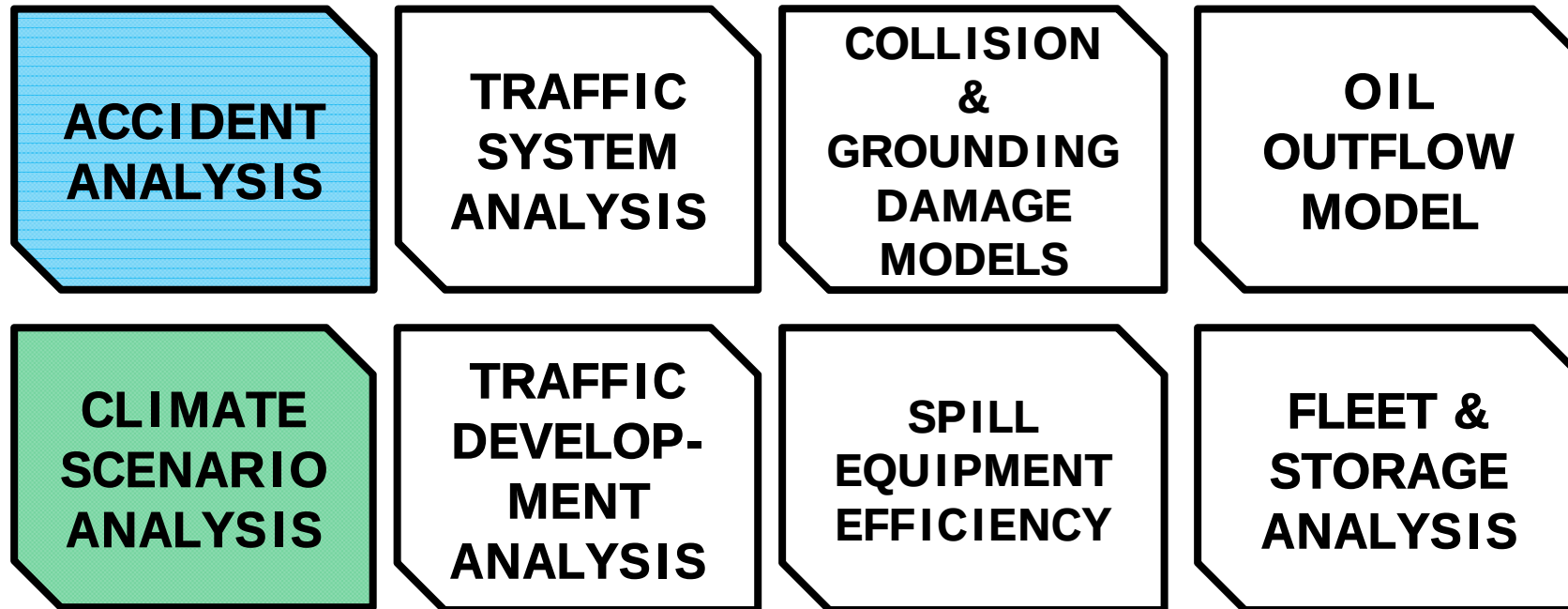


Aalto University
School of Engineering

Strategic risk management: oil spills



Overview: elements of strategic risk management model

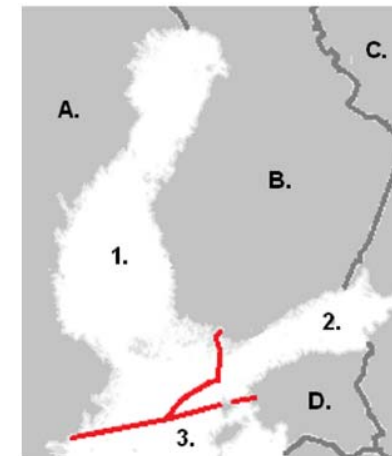
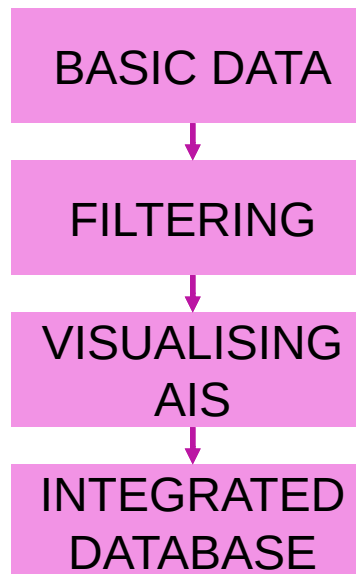


Accident analysis

Table 3
Summary of data in the constructed North BAceD + database.

Data field	Unit	Source	Categories/Additional notes
<i>General accident characteristics</i>			
Date	[-]	NDB	Format: dd.mm.yyyy
Time	[-]	AIS-V	Format: hh:mm:ss
Location	[-]	NDB, AIS-V	WGS-84 coordinates
Sea area	[-]	AIS-V, SC	{Port area, Archipelagic water way, Open sea}
Accident type	[-]	NDB, AIS-V	{Stranding/grounding/bottom contact, Collision with an object, Collision with other vessel} ^a
Operation type	[-]	AIS-V	{Independent navigation, Escort, Convoy, Cut loose, Drifting}
<i>Vessel characteristics (in case of collision with other vessel: struck ship)</i>			
Name	[-]	NDB	
IMO number	[-]	NDB, VDB	
MMSI number	[-]	VDB, AIS-V	
Ship type	[-]	VDB, AIS-V	{Work vessel, Tanker, Bulk carrier, Cargo vessel, RoPax, Icebreaker}
Gross Tonnage	[-]	VDB	
Deadweight	[tonnes]	VDB	
Length	[m]	VDB, AIS-V	
Breadth	[m]	VDB, AIS-V	
<i>Vessel characteristics (only in case of collision with other vessel: striking ship)</i>			
Name	[-]	NDB	
IMO number	[-]	NDB, VDB	
MMSI number	[-]	VDB, AIS-V	
Ship type	[-]	VDB, AIS-V	{Work vessel, Tanker, Bulk carrier, Cargo vessel, RoPax, Icebreaker}
Gross Tonnage	[-]	VDB	
Deadweight	[tonnes]	VDB	
Length	[m]	VDB, AIS-V	
Breadth	[m]	VDB, AIS-V	
<i>Sea ice conditions</i>			
Ice type	[-]	IC	{No ice, Level ice, Slightly ridged ice, Ridged ice, Heavily ridged ice}
Ice concentration	[%]	HIROMB	Fraction of area covered with sea ice relative to total area
Level ice thickness	[m]	HIROMB	Thickness derived from total mass of ice per unit area
Ice ridge density	[km ⁻¹]	HIROMB	Number of ridges per unit distance
Ridge height	[m]	HIROMB	Average height of pressure ridge in the area (sail and keel)
Snow depth	[m]	HIROMB	Thickness of the snow layer
<i>Atmospheric conditions</i>			
Light conditions	[-]	AA	{Daylight, Twilight, Night}
Visibility	[nm]	PMP	
Cloud cover	[%]	MESAN	
Wind speed	[m/s]	MESAN	
Wind gust	[m/s]	MESAN	
Wind direction	[-]	MESAN	{N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW}
Precipitation type	[-]	PMP	{No precipitation, Drizzle, Rain, Snow and rain, Snow}
Precipitation amount	[g/m ² h]	PMP	
Temperature	[°C]	PMP	
<i>Impact conditions</i>			
Impact speed vessel 1	[kn]	AIS-V	In case of ship-ship collision: struck vessel
Impact speed vessel 2	[kn]	AIS-V	Only in case of ship-ship collision: striking vessel
Impact angle	[°]	AIS-V	Angle between centre lines, measured from struck vessel's stern
Impact location	[-]	AIS-V	Location on the struck vessel hull: {Bow, Side, Stern}

ACCIDENT ANALYSIS



- 1. Bothnian Bay
- 2. Gulf of Finland
- 3. Baltic Proper
- A. Sweden
- B. Finland
- C. Russian Federation
- D. Estonia

Accident analysis

ACCIDENT ANALYSIS

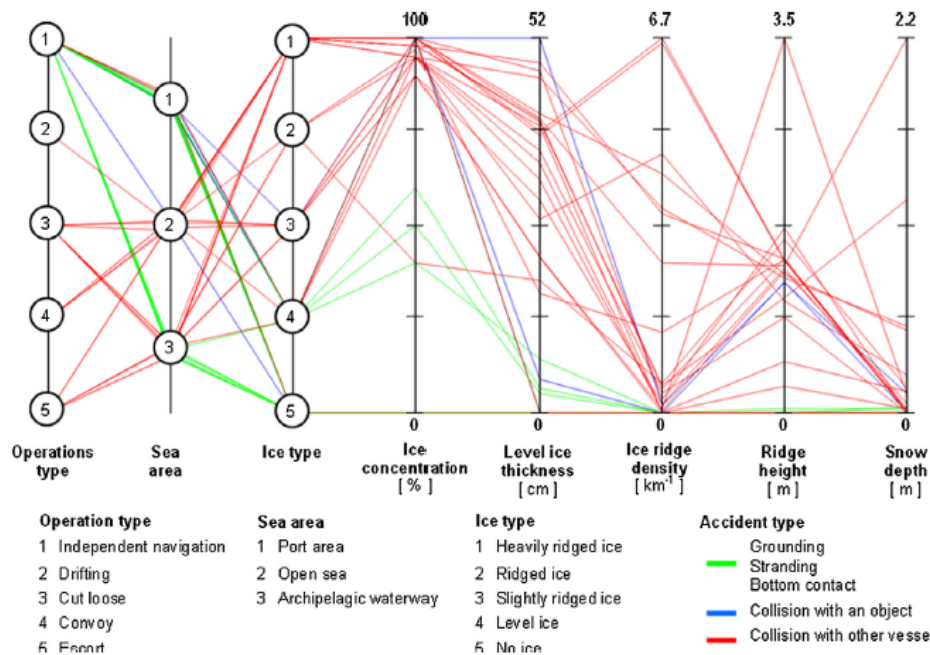


Fig. 4. Winter navigation accidents in relation to sea ice conditions.

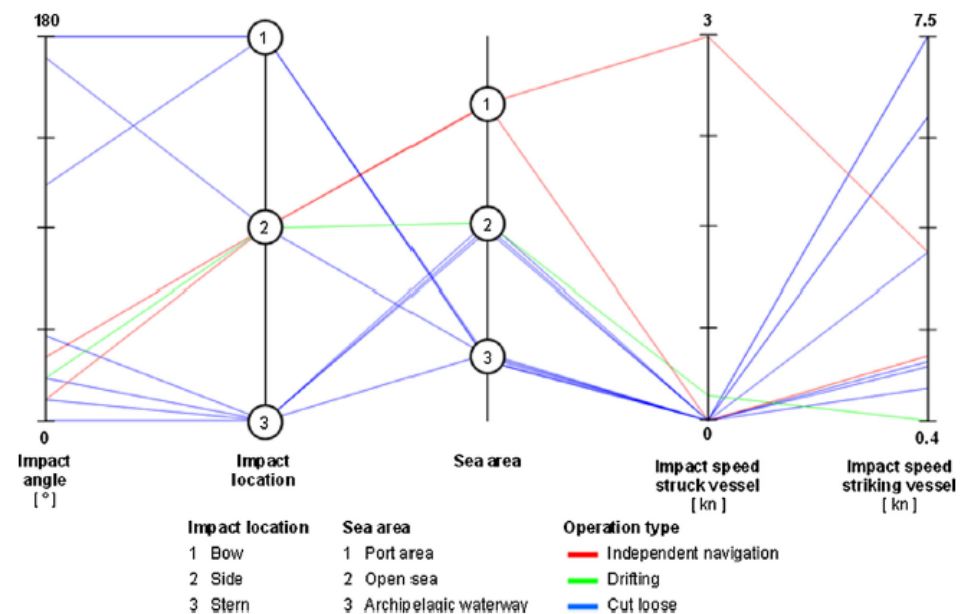


Fig. 9. Winter navigation ship-ship collision accidents in relation to impact conditions: cut loose, drifting and independent navigation.

Climate scenario analysis

CLIMATE SCENARIO ANALYSIS

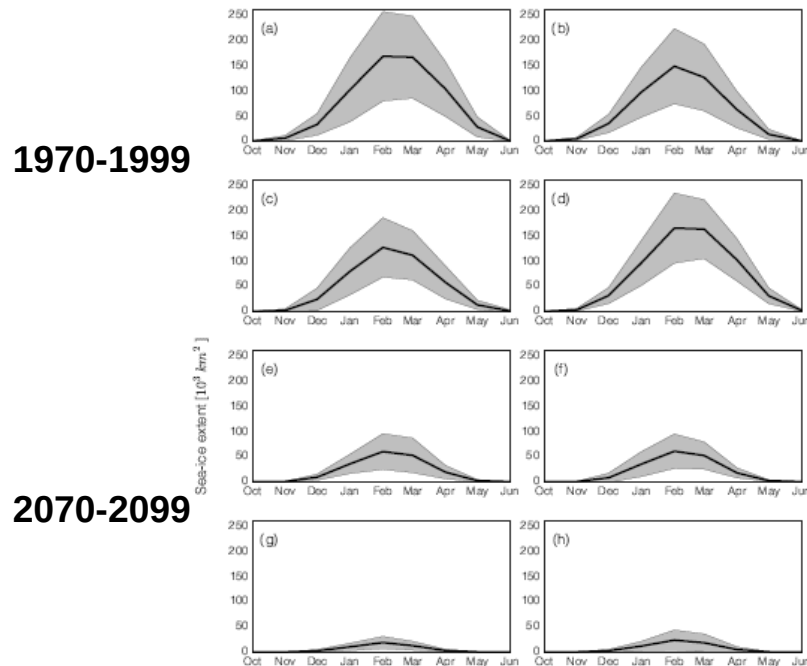


Figure 2: Long-term monthly Baltic Sea sea-ice extent [10^3 km^2] for (a) BASIS (1970–1999), (b) hindcast (1970–1999), (c) MPI historical (1970–1999), (d) EC-Earth historical (1970–1999), (e) MPI RCP4.5 (2070–2099), (f) EC-Earth RCP4.5 (2070–2099), (g) MPI RCP8.5 (2070–2099) and (h) EC-Earth RCP8.5 (2070–2099).

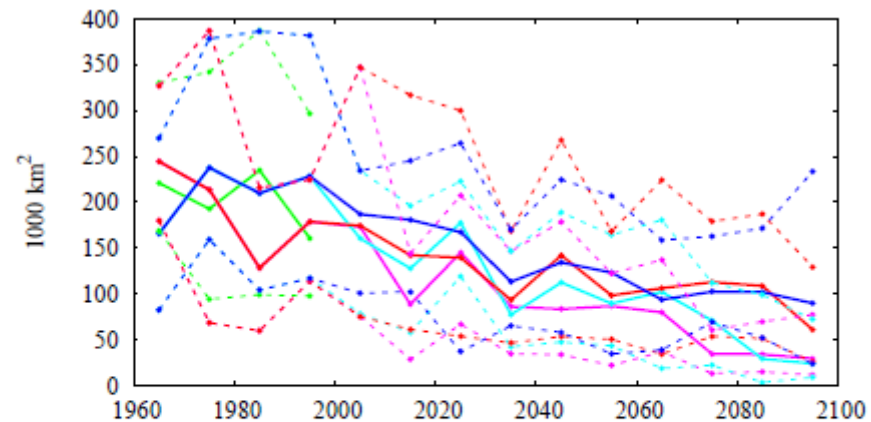


Figure 3: Decadal mean (solid) and decadal minimum and maximum (dashed) of annual maximum ice extent of the Baltic Sea from the hindcast (green), EC-Earth RCP4.5 (blue), EC-Earth RCP8.5 (light blue), MPI RCP4.5 (red) and MPI RCP8.5 (purple).

Climate scenario analysis

CLIMATE
SCENARIO
ANALYSIS

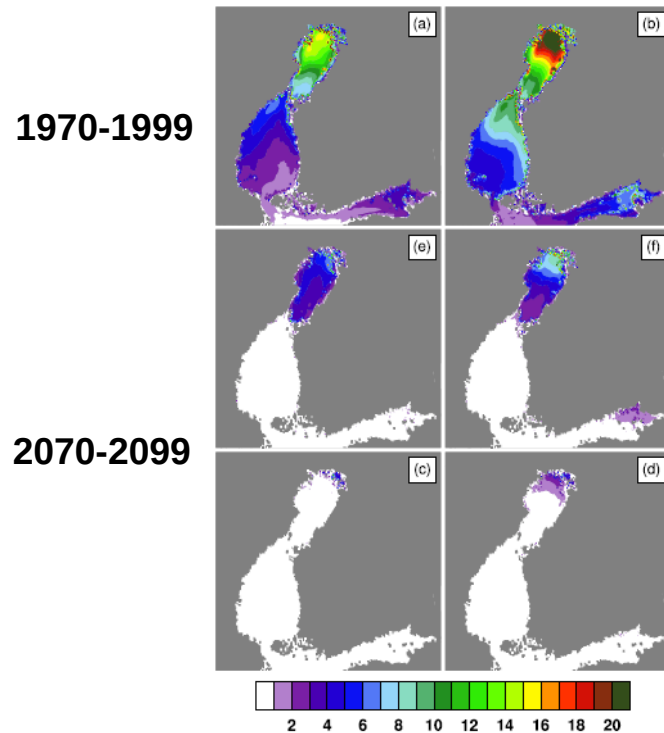


Figure 8: Mean March–April sea-ice concentration (%) in category 5 for (a–b) control period, (c–d) RCP4.5 scenarios and (e–f) RCP8.5 scenarios. (a–b) are averaged over the period 1970–1999 and (c–f) over the period 2070–2099. The left and right columns are the MPI driven and EC-Earth driven simulations, respectively.

1970–1999

2070–2099

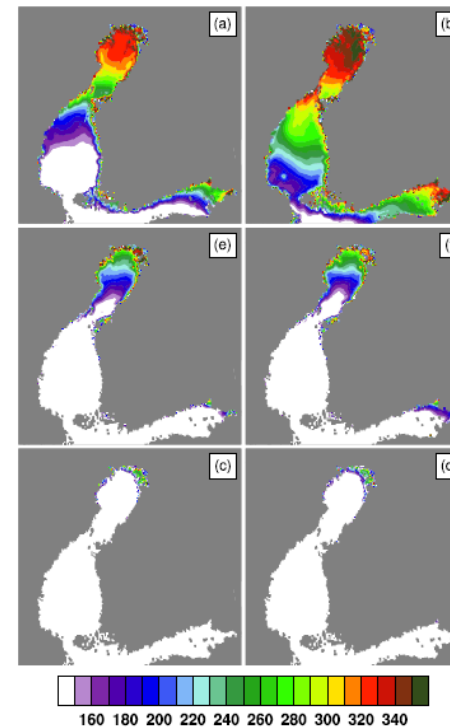


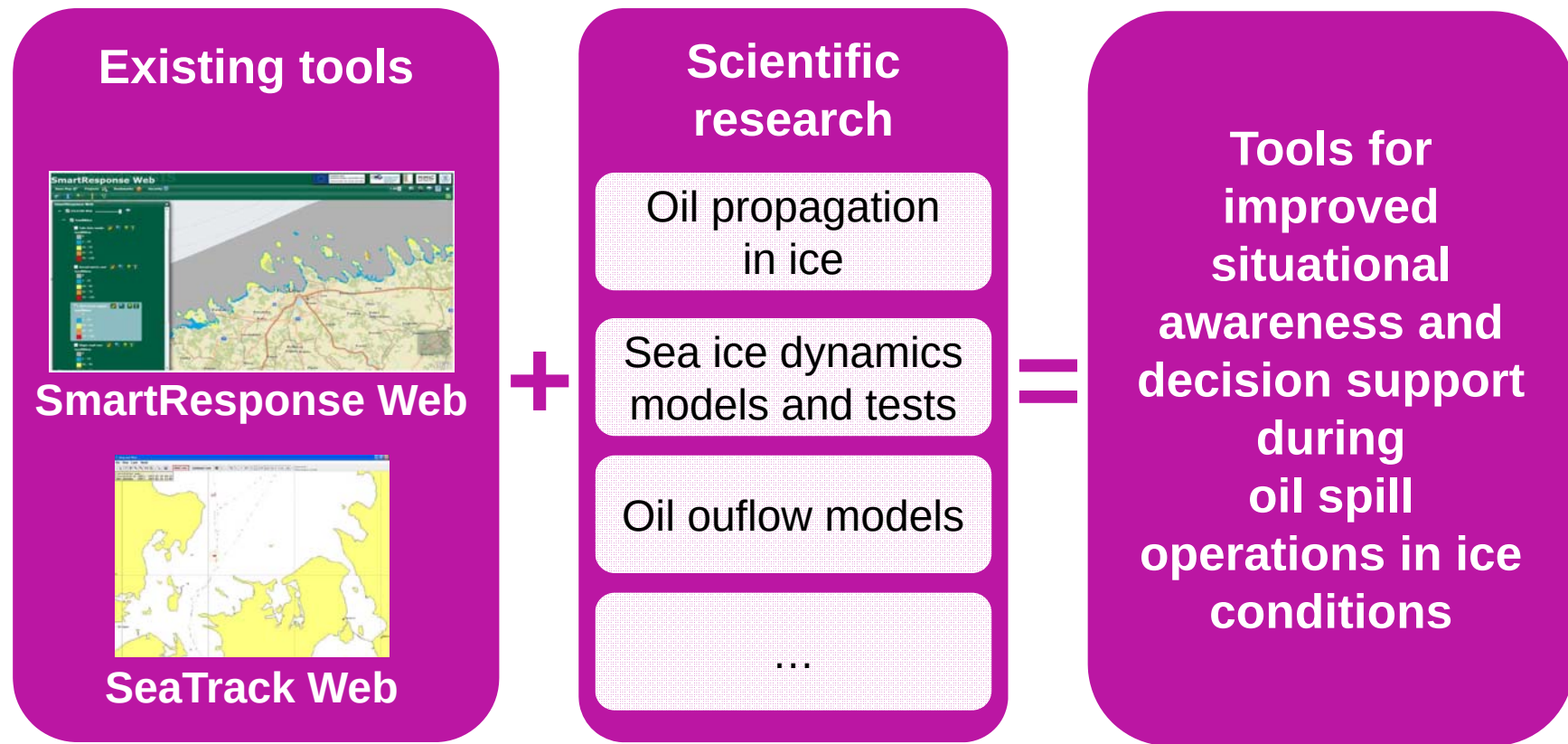
Figure 9: Same as in Fig 8 but for sea-ice thickness (cm) in category 5.

Operational oil spill risk management



Aalto University
School of Engineering

Operational risk management: oil spills



Overview: elements of operational risk management model

**COLLISION &
GROUNDING
DAMAGE
MODELS**

**OIL
OUTFLOW
MODEL**

**OIL
PROPAGATION
(SeaTrackWeb)**

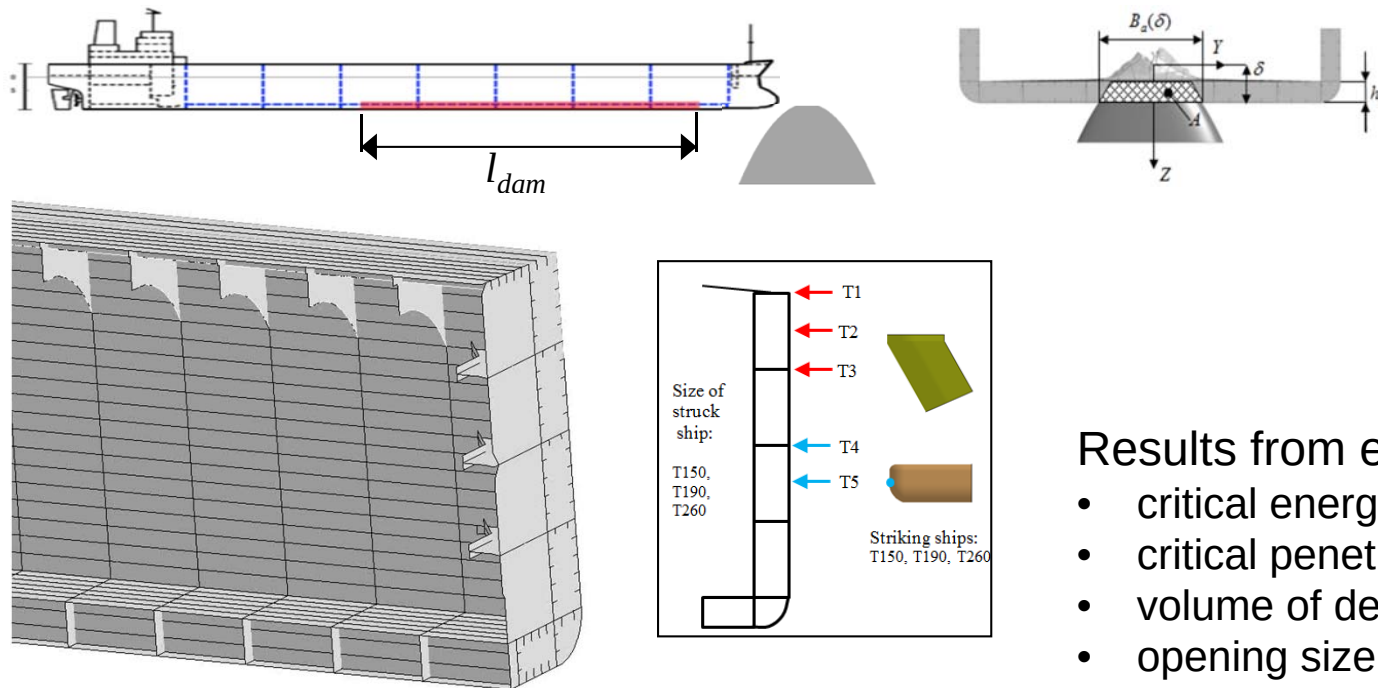
**WEB-BASED
SHIP SPILL
APPLICATION
(ADSAM)**

**GIS LAYER
TOOLS**

**SmartResponse
Web**

Collision and grounding damage models

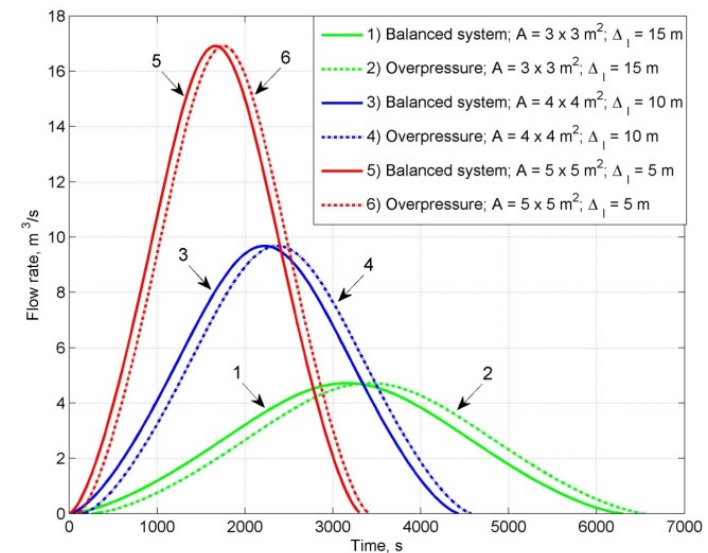
COLLISION & GROUNDING DAMAGE MODELS



Results from each simulation:

- critical energy
- critical penetration
- volume of deformed material
- opening size

OIL OUTFLOW MODEL



Web-based ship spill application (ADSAM)

WEB-BASED SHIP SPILL APPLICATION (ADSAM)

a) Input parameters

Single scenario

Type of accident
Grounding

Rock size [m]
3

Penetration [m]
5

c_t_scale
-1

Rock location in longitudinal
-1

Rock location in transverse
-1

Run Model

b) Visual representation of bottom damage

Struck Ship

Ships
T200

Ship name
T200

Length [m]
200

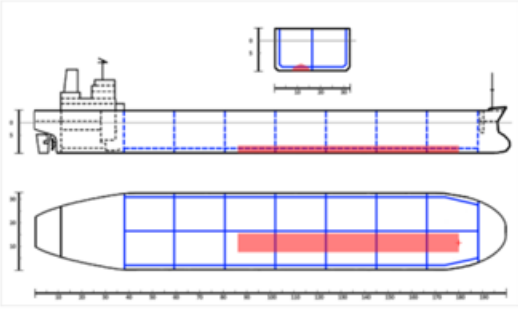
Ship type
Oil Tanker

Service speed [m/s]
8

Service speed [knots]
15.55

Level 2 parameters

Results



Damage length [m] 93.83

Inner penetration [m] 6.42

Spilled oil [m³] 3126163.52

Time 2175.64

Generate Report

c) Grounding scenario report

Ship parameters			
Name	T200	Block coefficient	0,77
Type	Oil Tanker	Mass [kg]	61615,32
Length [m]	200,00	Tanks (longitudinal)	7
Service speed [m/s]	8,00	Tanks (transverse)	2
Service speed [knots]	15,60	Tanks total	14
Breadth [m]	32,93	Double bottom height [m]	2,00
Draft (fully loaded) [m]	12,15	Breadth of double hull [m]	2,00
Depth [m]	17,40	Cargo type	Crude oil
Deadweight [t]	51807,96	Cargo density	865,00

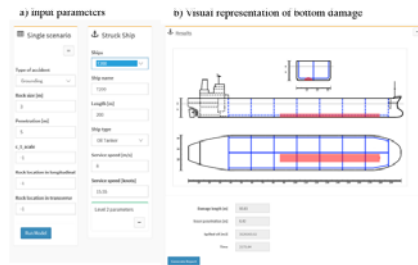
Scenario		
Rock size [m]	4,00	Rock location (longitudinal) -1,00
Penetration [m]	3,00	Rock location (transverse) -1,00
c_t_scale	-1,00	

Damage		Oil spill	
Length [m]	93,83	Volume (m³)	3126163,52
Inner width [m]	6,42	Duration	2175,64
Outer width [m]	8,02		

SmartResponse Web

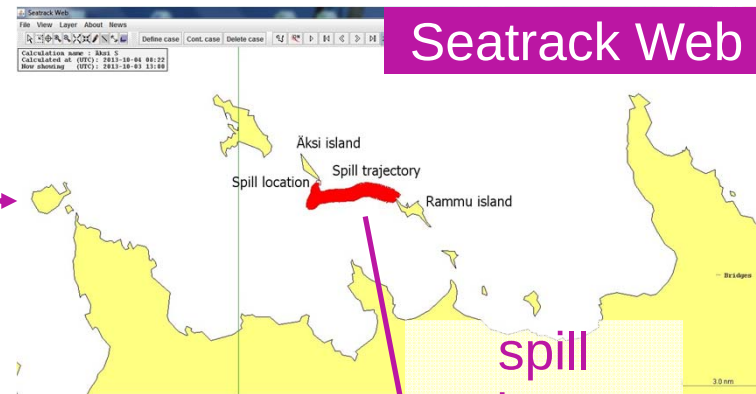
SmartResponse
Web

ADSAM

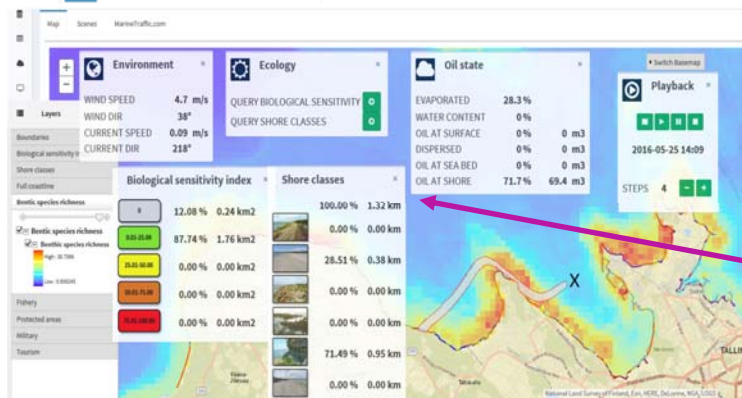


spill
amount

Seatrack Web

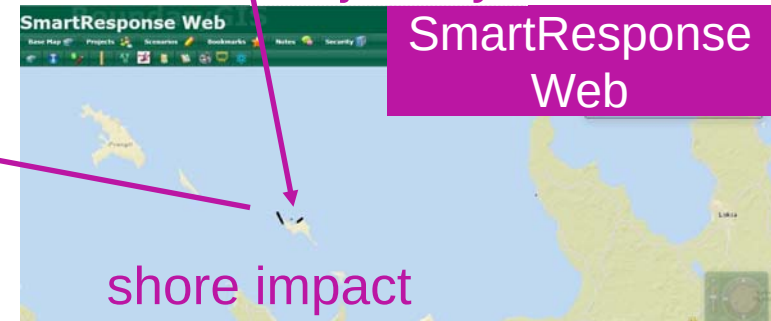


spill
trajectory



Environmental Sensitivity Index

SmartResponse
Web



shore impact

STORMWINDS Consortium





Aalto University
School of Engineering

Thank you!

www.stormwinds.aalto.fi

Floris Goerlandt, D.Sc. (Tech)

floris.goerlandt@aalto.fi

+358 50 343 1186





Aalto University
School of Engineering



Strategic and Operational Risk Management for Wintertime Maritime Transportation System

*Aalto University
Research Group on Maritime Risk and Safety*