Interreg Baltic Sea Region

Co-funded by the European Union

SUSTAINABLE WATERS
OpenRisk II

KYSTVERKET
NORWEGIAN COASTAL ADMINISTRATION

GDAŃSK UNIVERSITY OF TECHNOLOGY

TOETAB

Aalto University

AISyRisk Baltic & Ice module

Jon-Arve Røyset, Norwegian Coastal Administration

Osiris Valdez Banda, Aalto University

Jakub Montewka, Gdansk University of Technology

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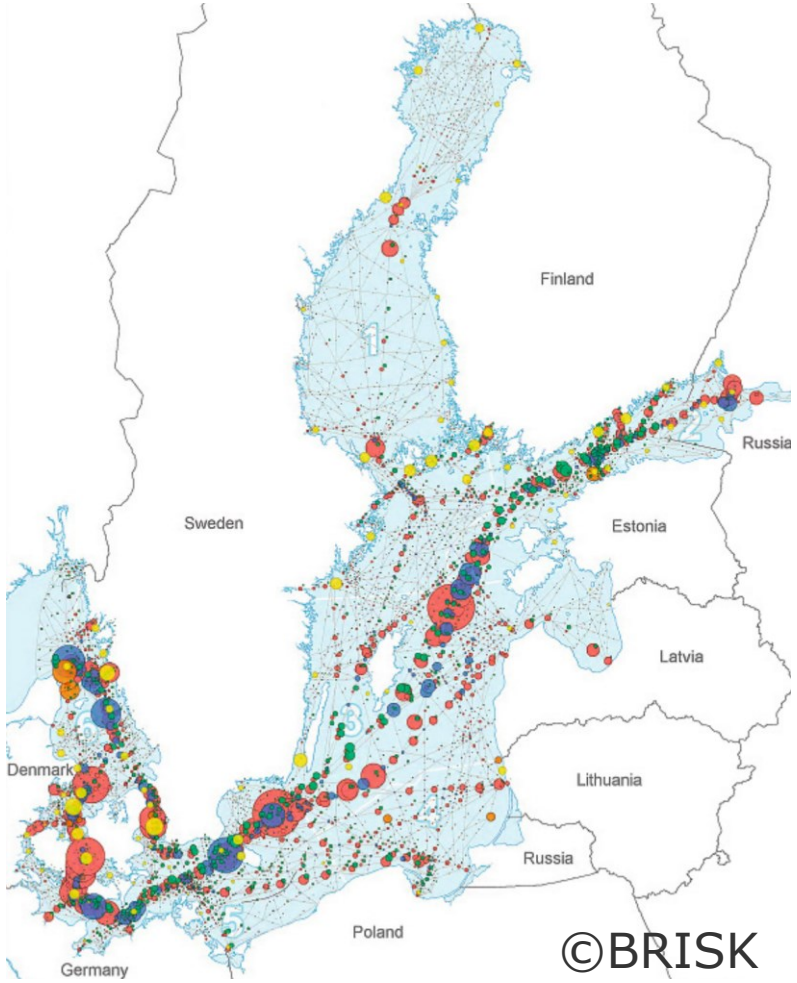
Risk model method

The risk model in AISyRisk considers a new methodology for the following accident types

- Powered grounding
- Drifting grounding
- Collision

Probability of foundering and fire/explosion is based on existing method

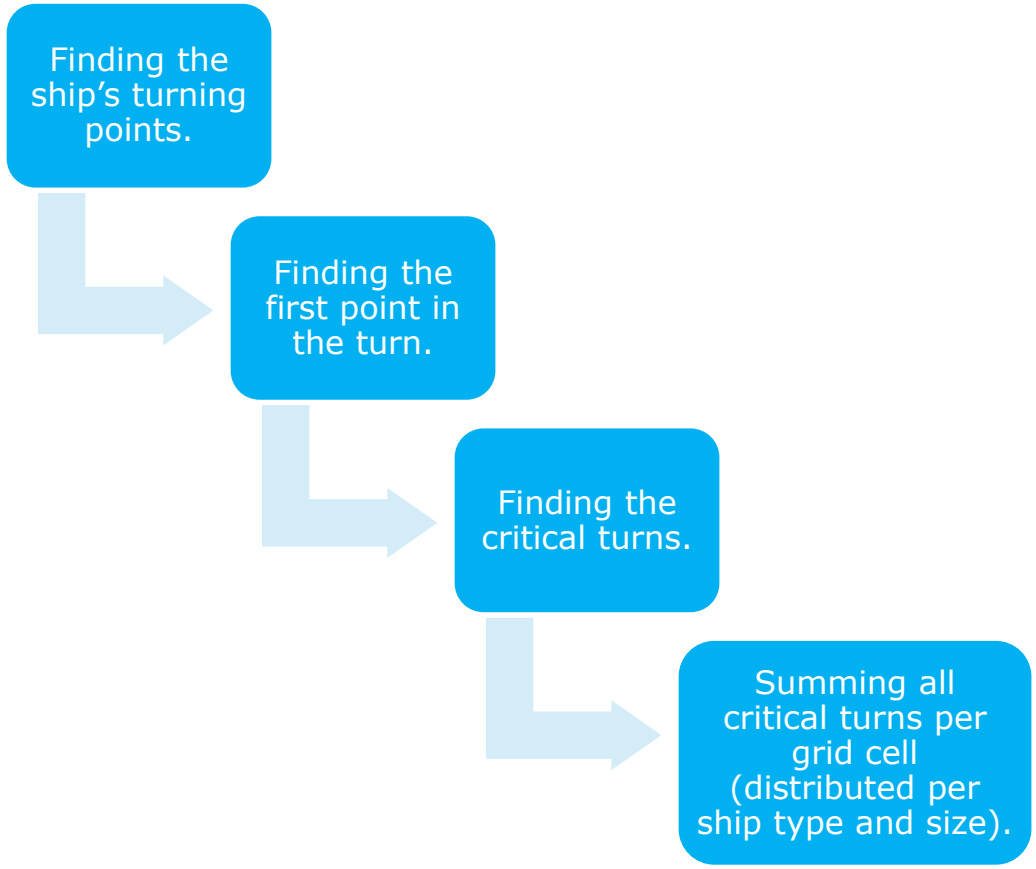


Powered grounding model – Type I: Critical turns

- Finds critical turns (where ships need to turn to avoid hitting land)

The outputs from the powered grounding type I candidate calculations are:

- Number of critical ship turns
- Location of the critical turns (latitude and longitude of the start point of the critical turn)
- Location of the hit point (latitude and longitude of the location for grounding)

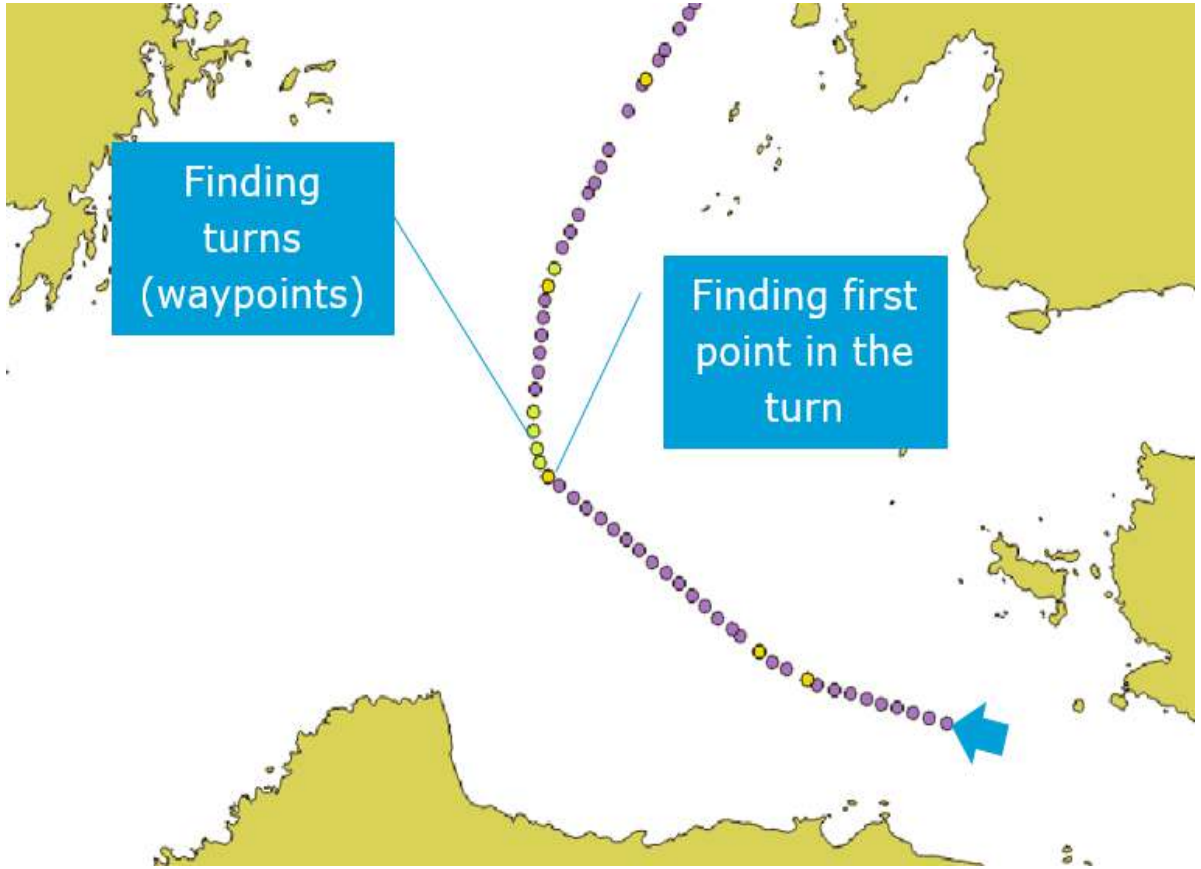


Accidents = Number of critical turns ("accident candidates") × Causation Probability (P_C)

Powered grounding model – Type I: Critical turns

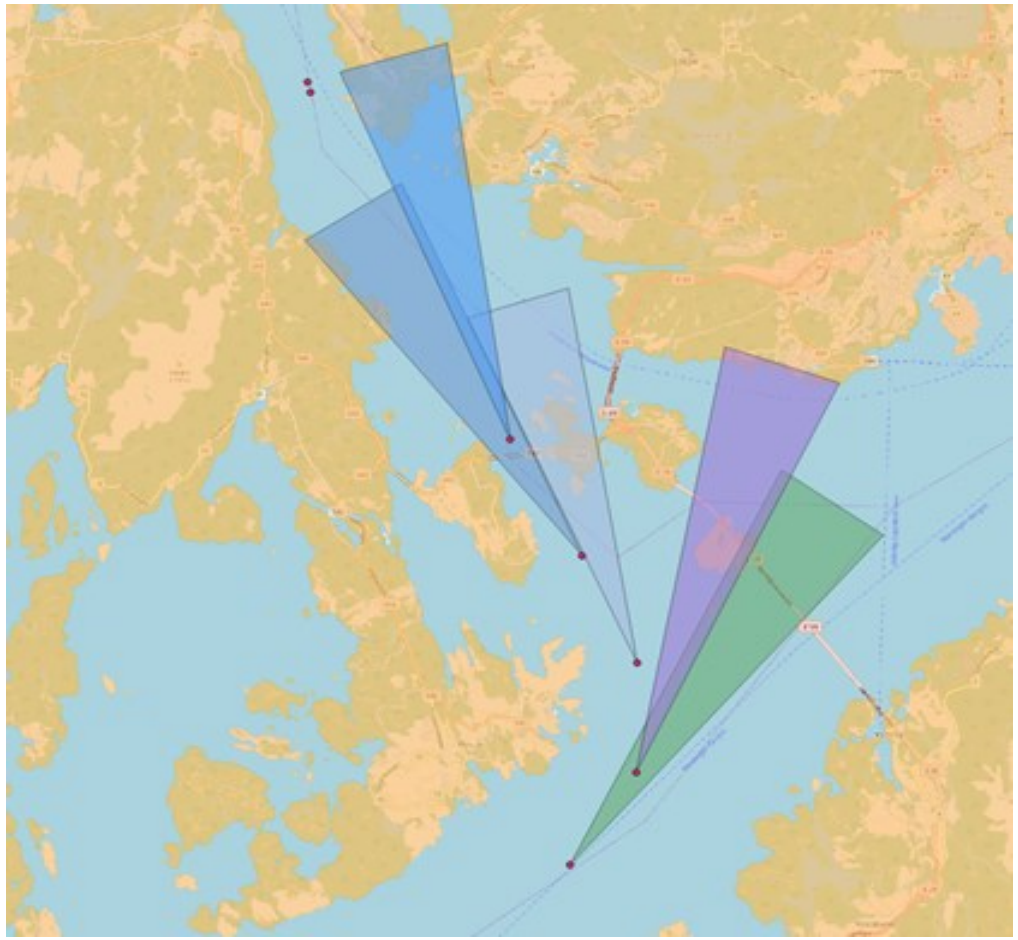
The following criteria apply for identifying critical turns:

- Difference in course over ground between adjacent points (30 seconds apart) higher than 5°
- 20-minute sector at start point of turns if the sectors cross land (incl. islands and shallow waters), after the point where the ship should turn



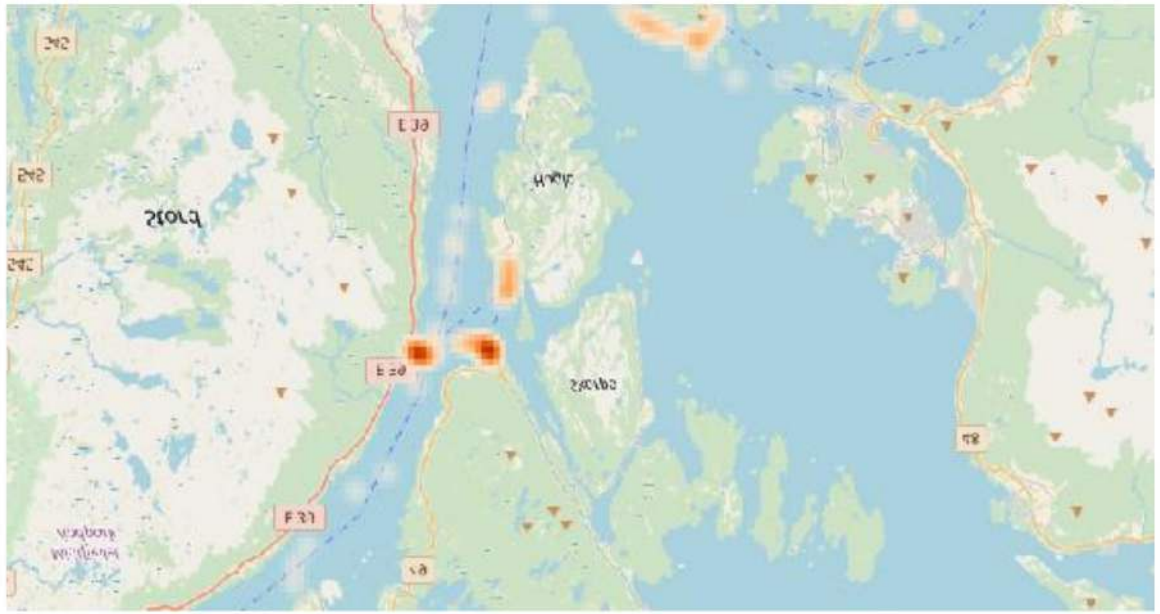
Powered grounding model – Type I: Critical turns

Illustration of 20 minute sectors that hit land created from the start points of turns (red)



Clustering of critical turns (red)

Clustering (gridded) of the critical turns showed on a heat map (high risk areas)



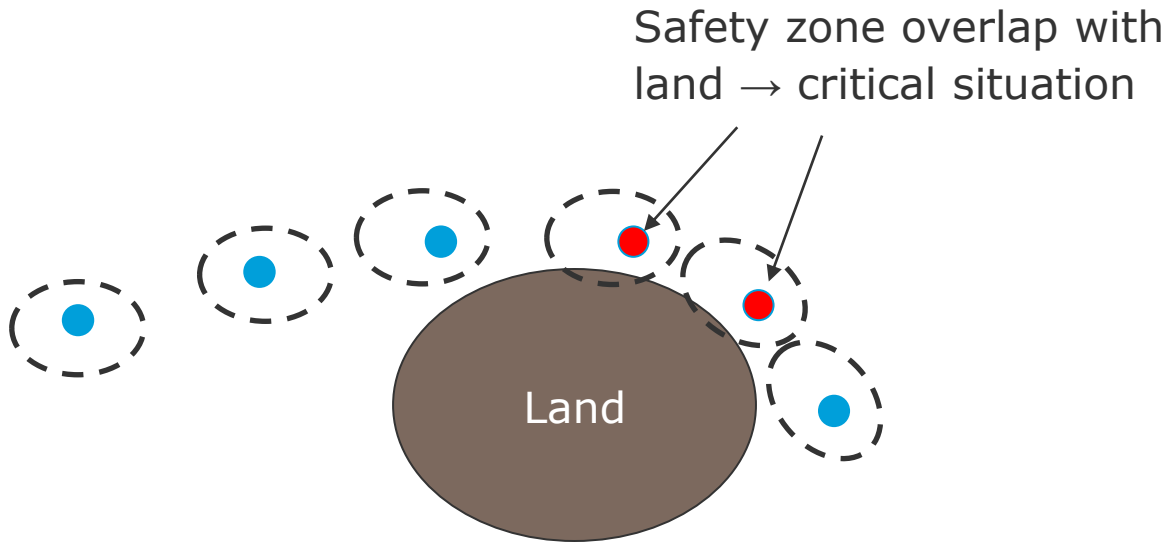
- Outputs

The outputs from the powered grounding type I candidate calculations are:

  - Number of critical ship turns.
  - Location of the critical turns (latitude and longitude of the start point of the critical turn).
  - Location of the hit point (latitude and longitude of the location for grounding).

Powered grounding model – Type II: Sailing close to land

- Grounding for ships sailing very close to shore or in shallow waters
- Establishing a "safety zone" around each vessel
  - Checks for when the safety zone overlaps with land or too shallow water → critical situation
- To capture causes: *Navigational error, unmarked reefs or rocks, misconceiving position etc.*

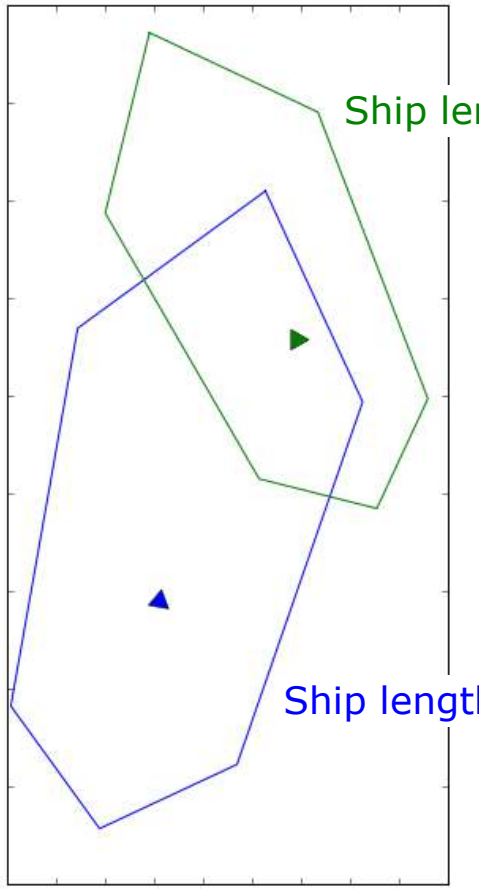


Accidents = Number of safety zone overlaps ("accident candidates") × Causation Probability (P_C)

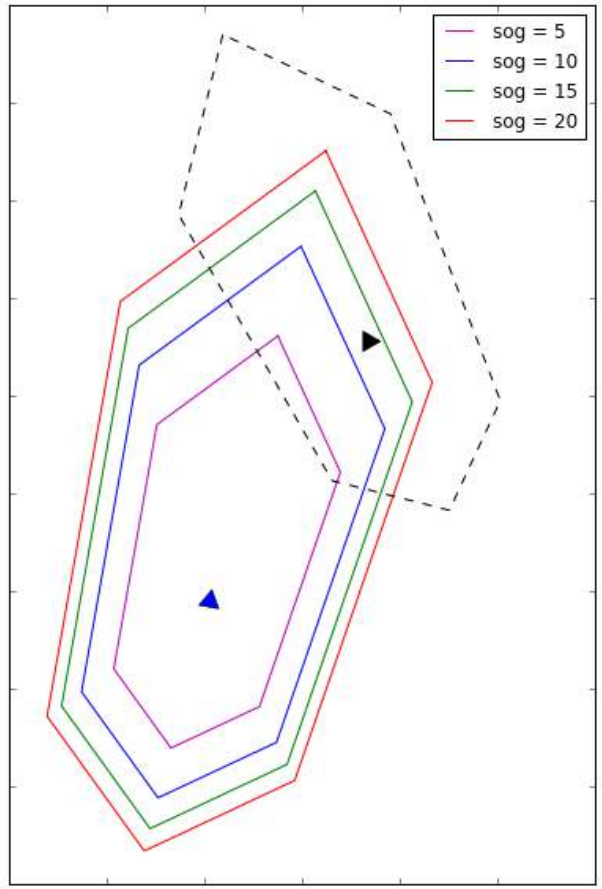
Collision

Collision – safety zone

Ship in safety zone

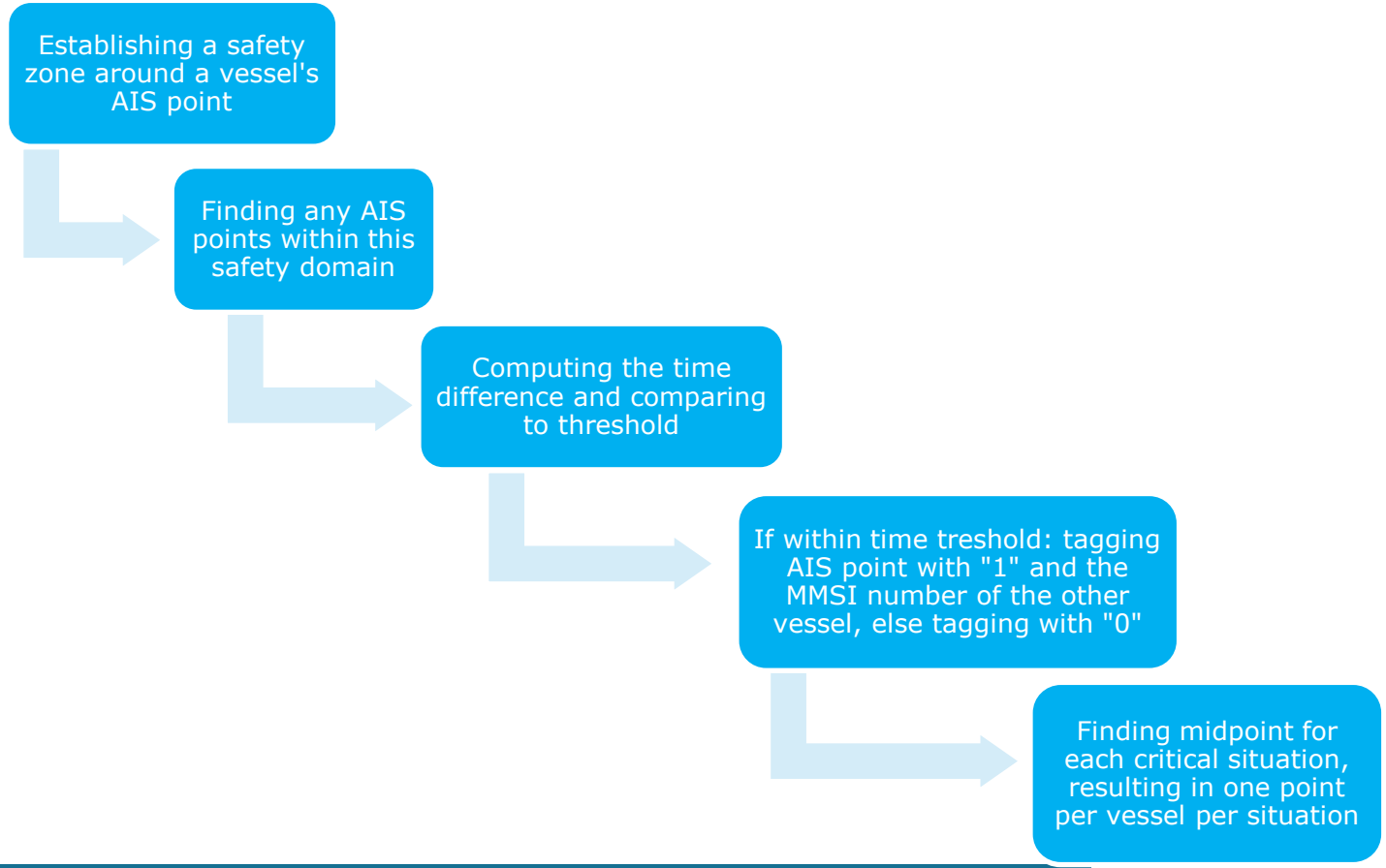


Safety zone dependence on speed



Collision

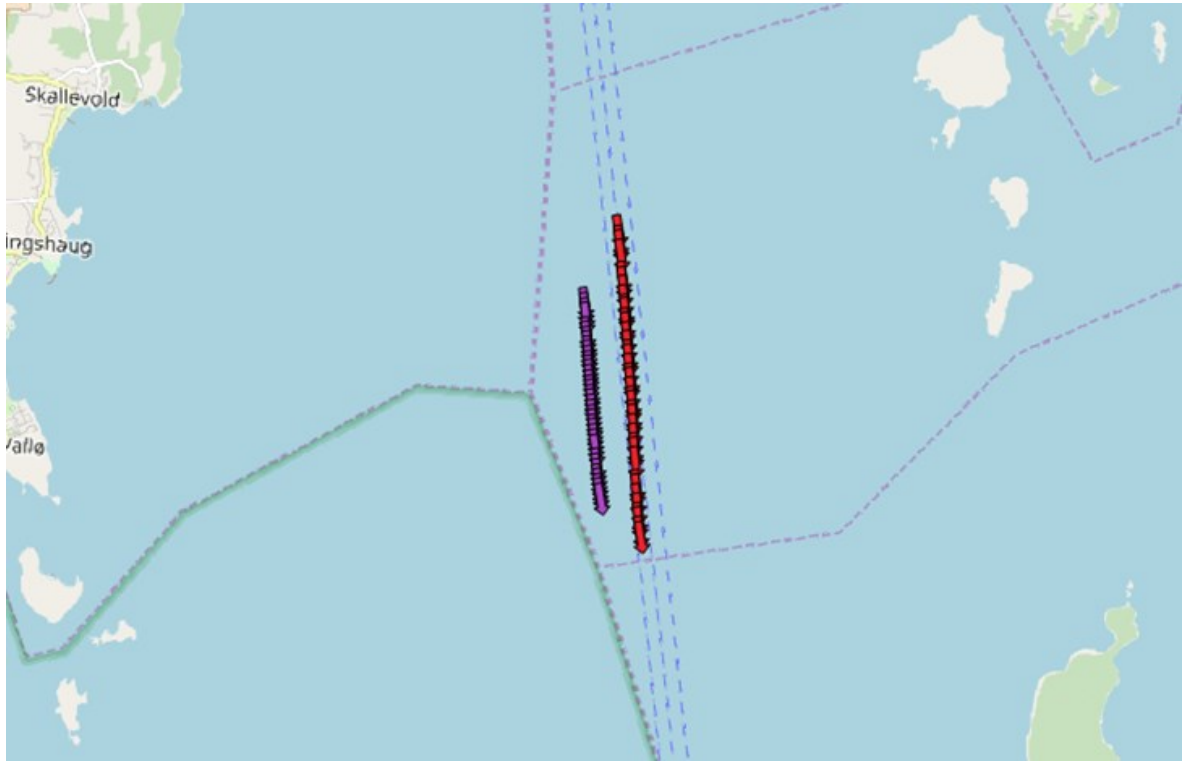
- The algorithm finds situations when one ship is inside another ship’s safety domain
  - *Not* overlapping safety domains
- The safety zones domains are based on ship dimensions, speed and the encounter type



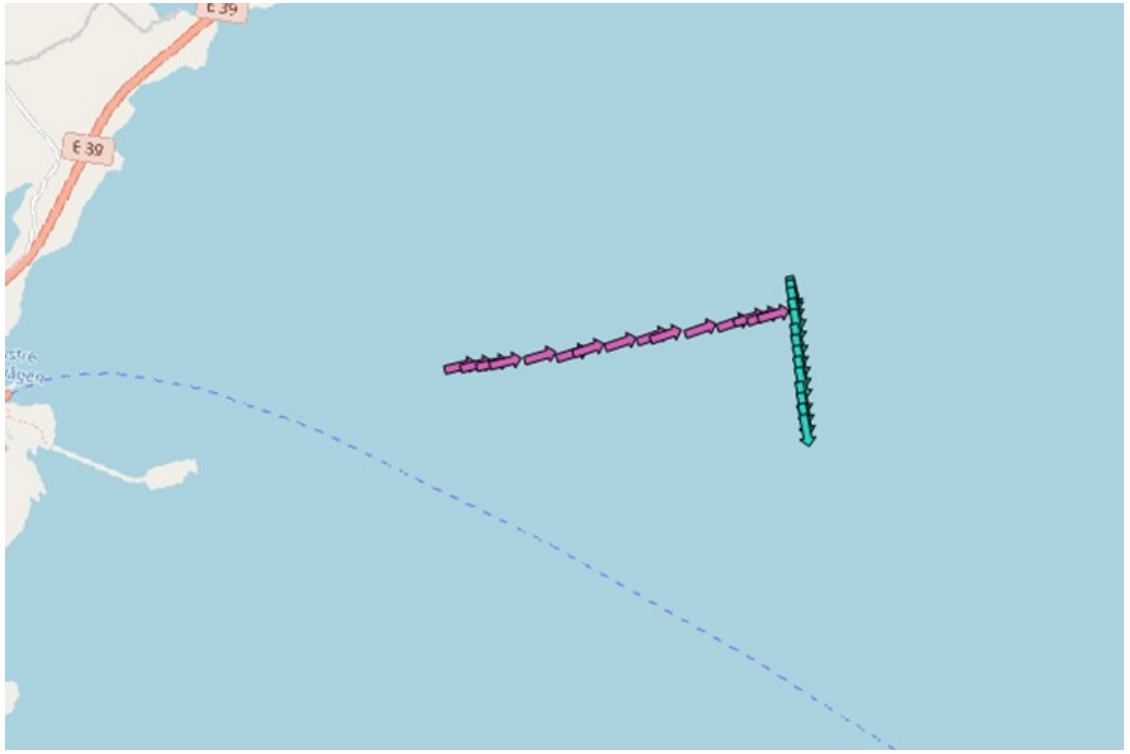
Accidents = Number of safety zone overlaps (“accident candidates”) × Causation Probability (P_C)

Collision – encounter types

Typical overtaking encounter



Typical crossing encounter

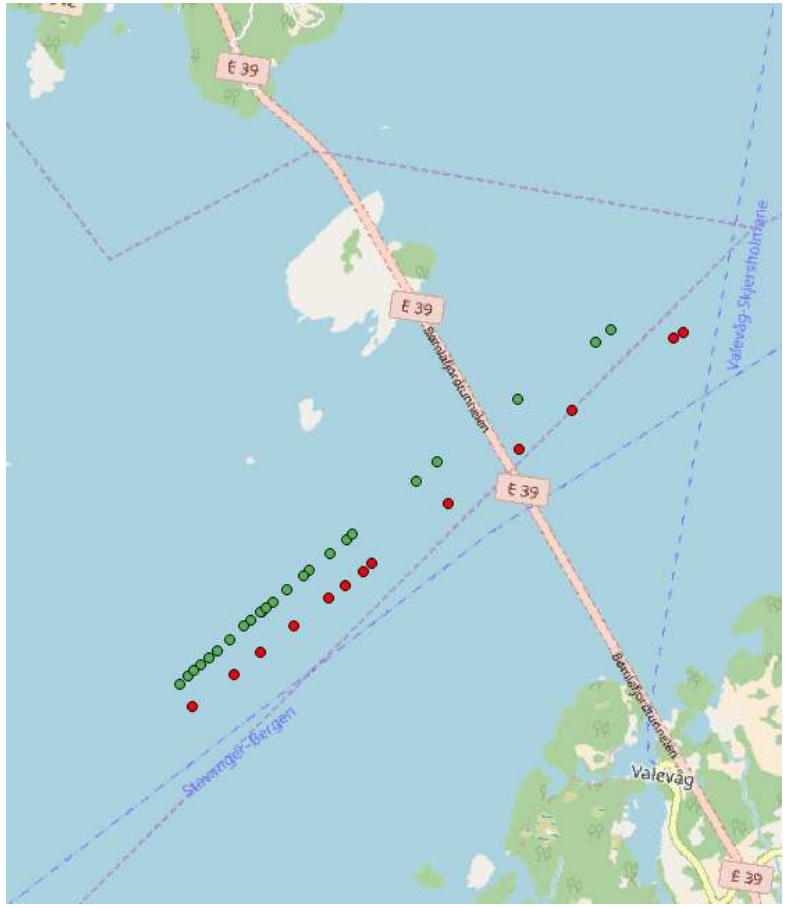


Collision – encounter types

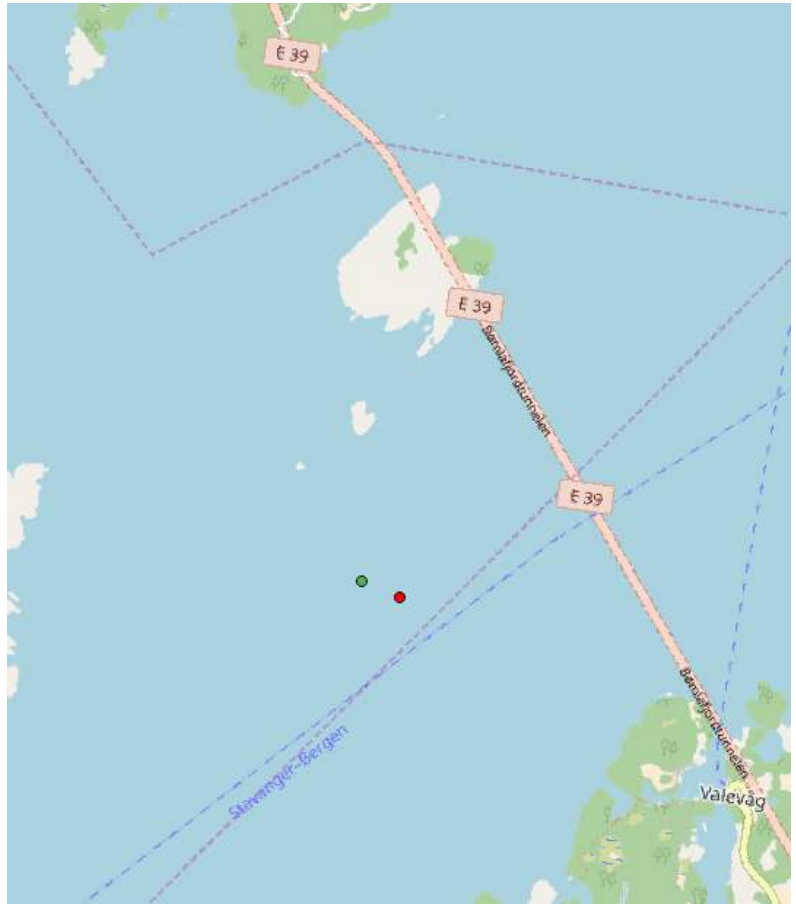
Typical head-on encounter

Example of how the collision algorithm works – finding the midpoints

Points in a collision candidate

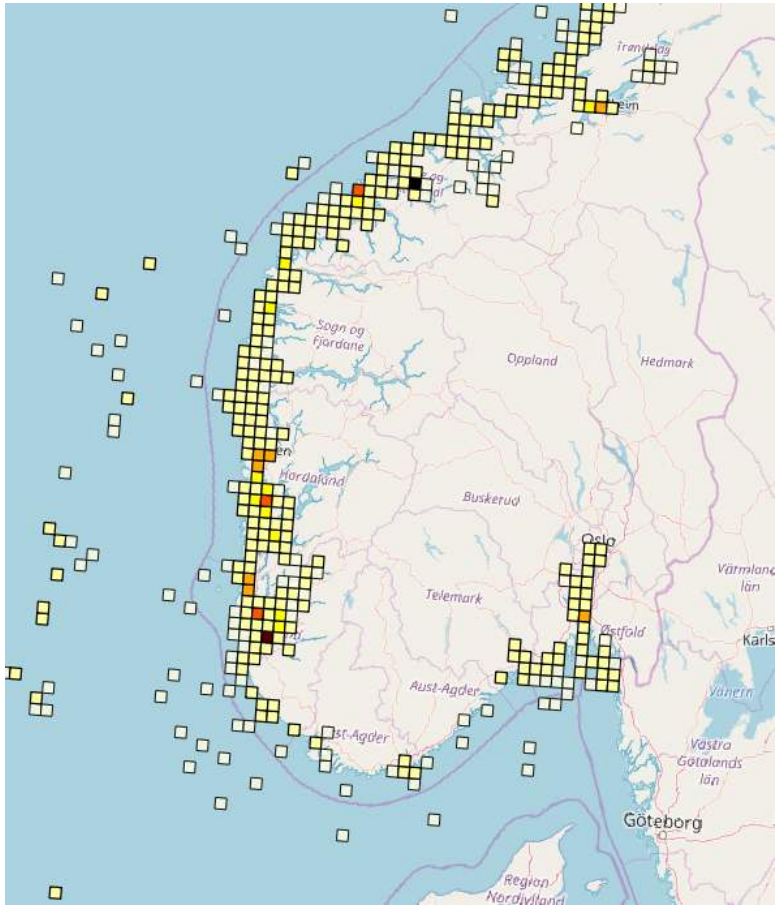


Collision midpoints to be aggregated

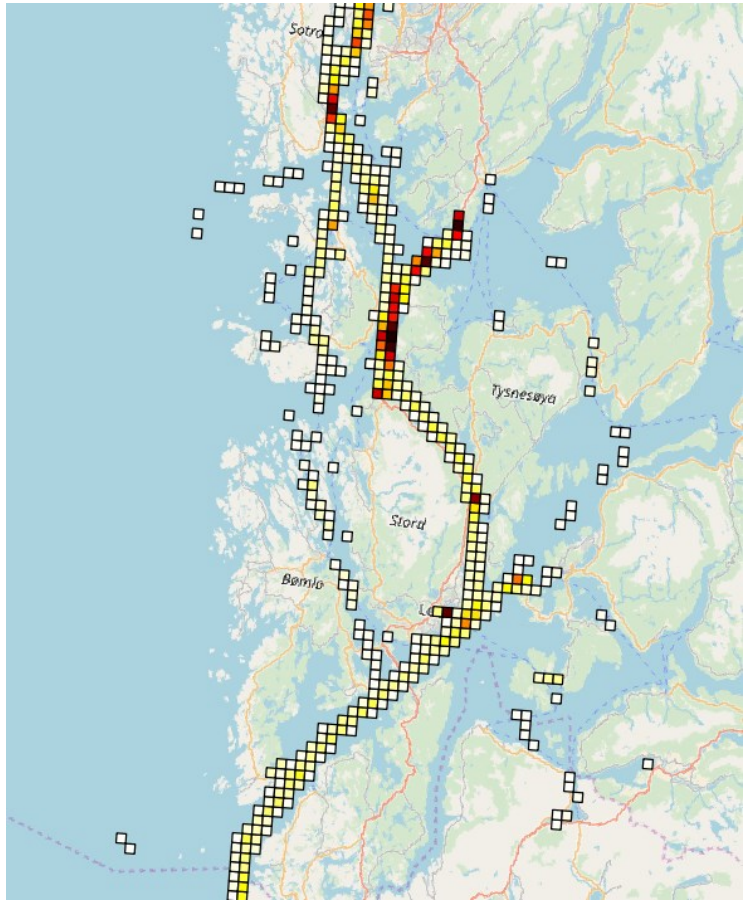


Collision results

10x10 km grid



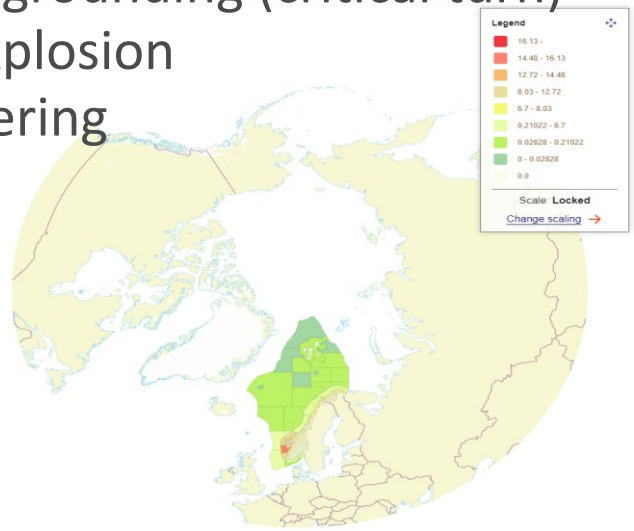
1x1 km grid



Ice module development

AISyRISK

Collision (crossing)
Collision (head on)
Collison (overtaking)
Drift grounding
Power grounding (close to shore)
Power grounding (critical turn)
Fire/explosion
Foundering



AISyRISK Ice module

Collision (crossing)
Collision (head on)
Collison (overtaking)
Drift grounding
Power grounding (close to shore)
Power grounding (critical turn)
Fire/explosion
Foundering
Collision under assistance
Ice damage
Besetting in ice

What shall we calculate?

Accident Types in Ice
Collision - Over taking Collision – Crossing) Collision - Head on
Drift Grounding
Powered Grounding (close to shore)
Powered Grounding (missed turn)
Foundering due to ice
Fire / explosion
Besetting in ice
Ice damage
Collision under assistance
= Existing accident type
= New accident type

The frequency / probability of an accident occurring is dependant on the operation mode of the ship and the ice conditions the ship operates in.

I.e. the frequency needs to change if certain operations modes or conditions are detected.

Consequences
Expected Fuel Spill Volume
Expected Cargo Spill Volume
Expected Fatalities
Cost? **No**
Time lost? **No**

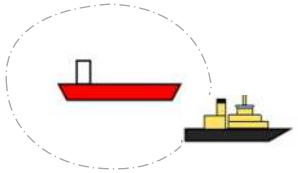
Operation modes (TRUE/FALSE)
1. Operating in ice
2. Independent operation in ice
3. Vessel following icebreaker
4. Vessel under tow
5. Vessel getting cut loose by icebreaker
6. Vessel sailing in convoy
7. Vessel sailing in an ice lead
8. Pressure ridges in ice regime
9. Glacier ice in ice regime
10. Vessel operating with positive Risk index
11. Vessel operating in remote areas
12. Operating in “light”/”harsh” ice conditions *Something representing the risk if ice navigation better then POLARIS. Representing the speed of the vessel through ice might be an option?*

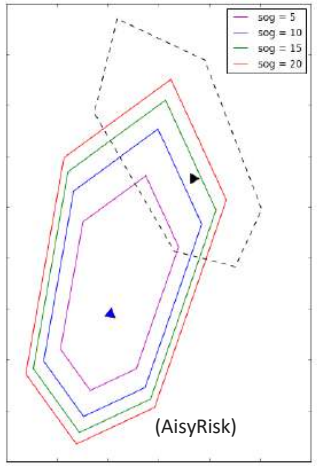
Collision under assistance

Operation modes

- Independent navigation 
- Escort 

- Convoy 

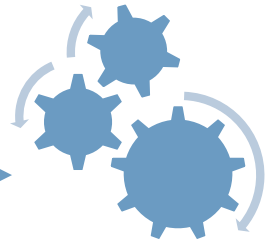
- Cutting loose 



$F = N \times P$

N – Accident candidate
P – Causation probability

Mode recognition



$F = N_m \times P_m$

m – Operation mode
N_m – Candidate in mode m
P_m – Causation probability in mode m

Operation mode recognition - example

- AIS data

February 2021

- Icebreaker

SISU (example)

- Designed detection methods

escort, convoy, cutting loose

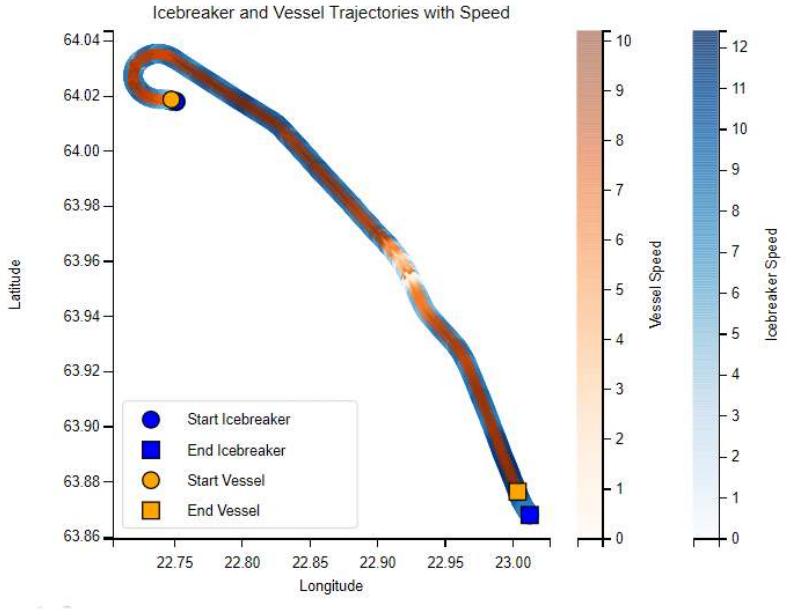
- IBNet data

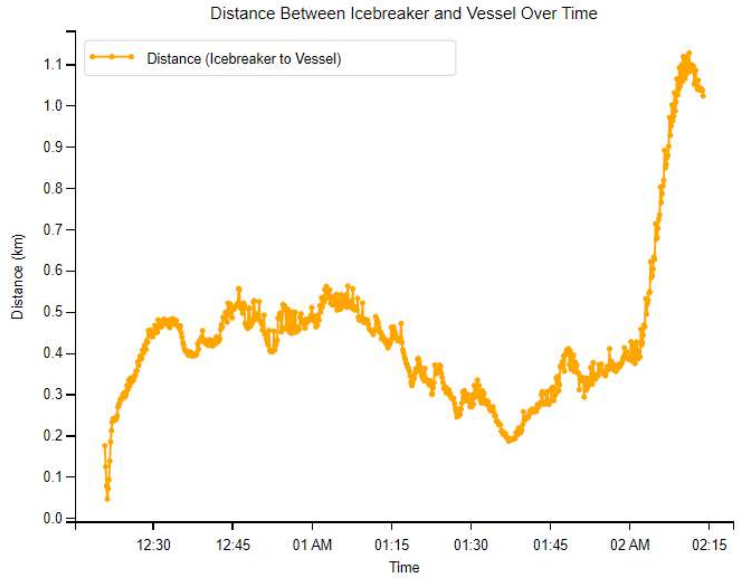
results comparison for escort and convoy

Example - Escort

❑ Model recognition:

- Escort start time : 2021-02-16 00:21:00; Escort end time : 2021-02-16 02:14:00





Trajectory of vessel in orange
Trajectory of icebreaker in blue

● Start point of trajectory

■ End point of trajectory

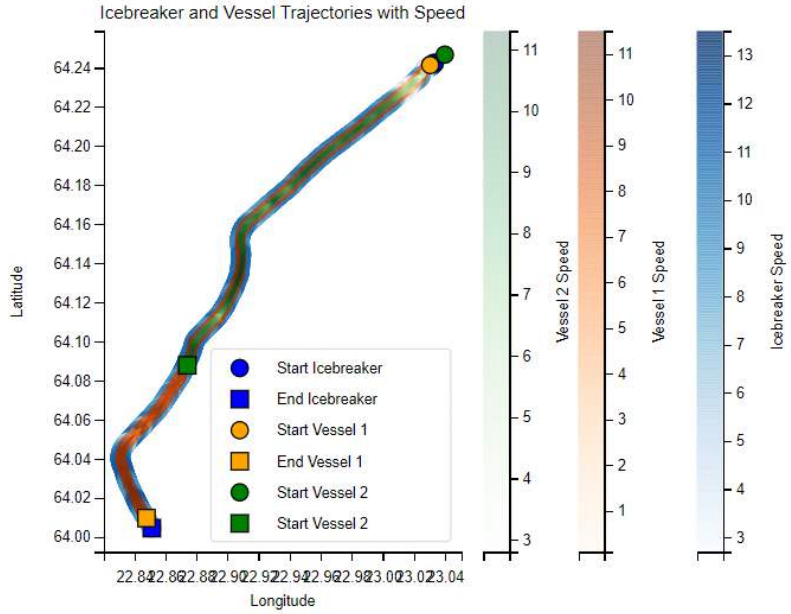
❑ IBNet record: * slight time difference compared to the record, but the record is entered manually

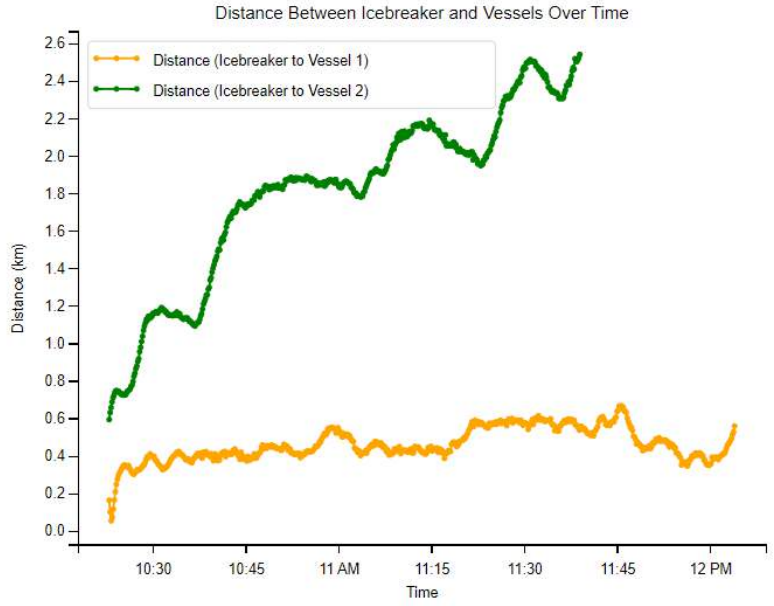
DTE	Ibstatus Starttime	IBSTATUS_ENDTIME	Icebreaker	Name	IMO	Avg convoy size	Duration
2021-02-16	00:25:00	2:20:00	SISU	**	**	1	1h55min

Example - Convoy

❑ Model recognition:

- Convoy start time : 2021-02-28 10:23:00; Convoy end time : 2021-02-28 11:39:00



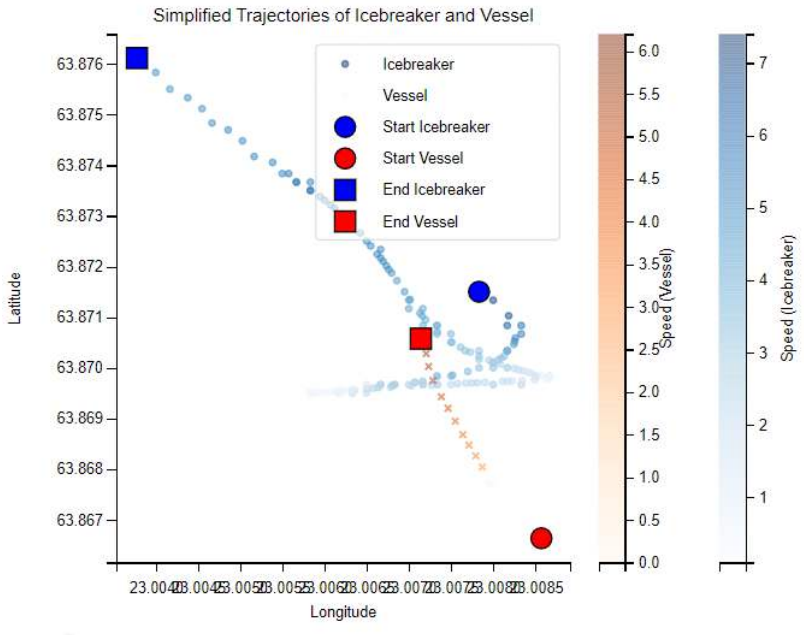


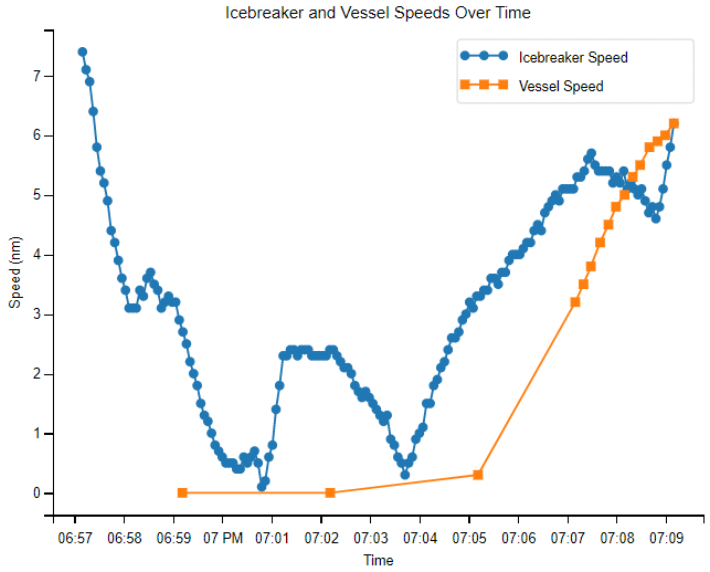
❑ IBNet record: Duration time of Vessel 1: 10:23:00 – 12:04:00; Duration time of Vessel 2: 10:23:00 – 11:39:00

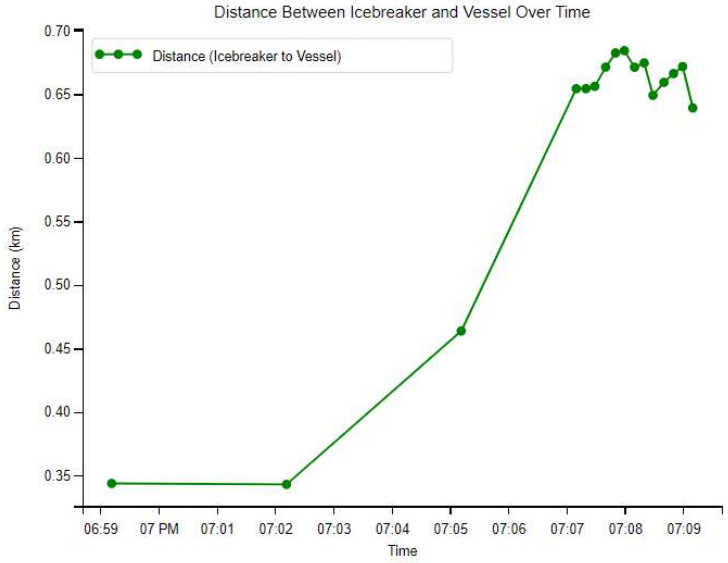
DTE	Ibstatus Starttime	IBSTATUS_ENDTIME	Icebreaker	Name	IMO	Avg convoy size	Duration
2021-02-28	10:15:00	11:40:00	SISU	**	**	2	1h25min
2021-02-28	11:40:00	12:05:00	SISU	**	**	1	25min

Example – Cutting loose

- Model recognition:
- Assistance end time: 2021-02-12 19:07:00 ⟶ Starting escort



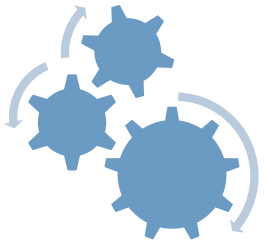




- IBNet record: N/A

Collision under assistance

Causation probability



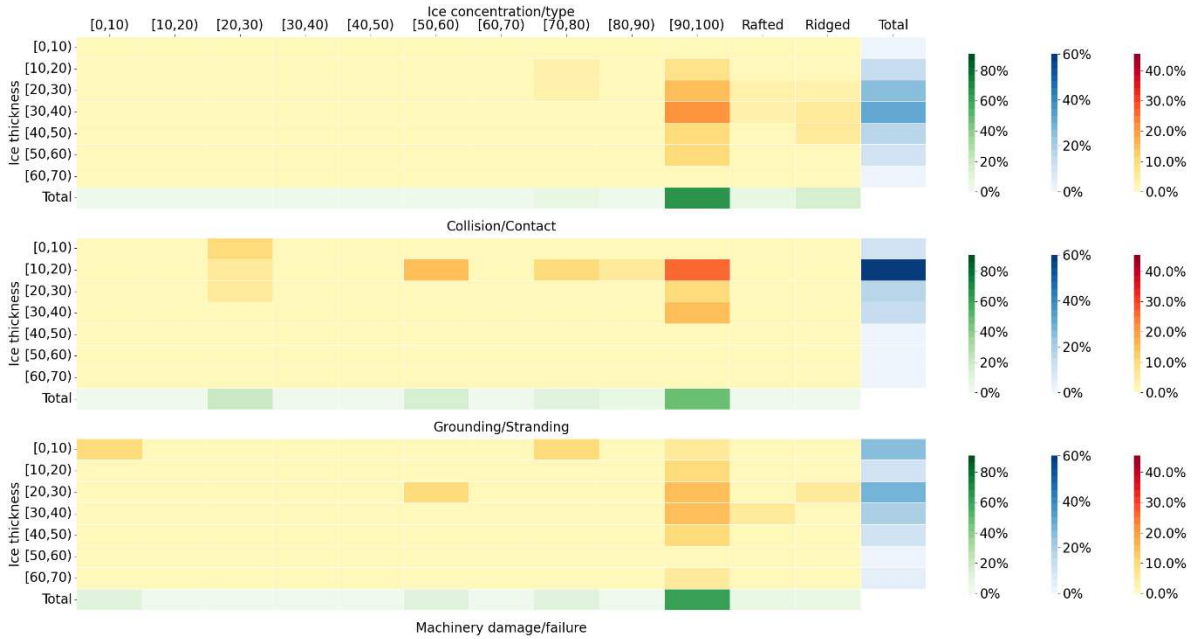
$F = N_m \times P_m$

m – Operation mode
N_m – Candidate in mode m
P_m – Causation probability in mode m

Operation	Average accidents per winter (4 winter periods[a])	Assisted vessels (3 winter periods[b])	Probability of accident per assisted vessel (3 winter periods[b])
IB assistance operations	5.00	21384	6.1E-04
Convoy	0.75/winter	–	1.4E-04
Cutting loose	0.25/winter	–	0.5E-04
Towing	2/winter	–	3.7E-04
Unknown	2/winter	–	0.9E-04

[a] Winter periods 2002–2003, 2009–2010, 2010–2011 and 2011–2012.
[b] Winter periods 2009–2010, 2010–2011 and 2011–2012.

Accident analysis

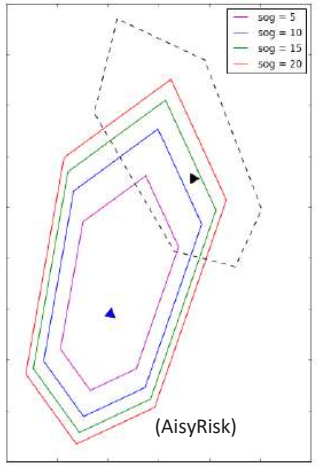


Establish causation probability distribution along ice condition

Collision under assistance

Operation modes

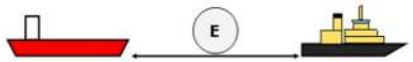
- Independent navigation



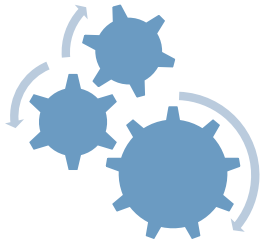
$F = N \times P$

N – Accident candidate
P – Causation probability

- Escort



- Convoy



$F = N_m \times P_m$

m – Operation mode
N_m – Candidate in mode m
P_m – Causation probability in mode m

- Cutting loose