

Big data for winter navigation in the Northern Baltic Sea: Developments and application opportunities

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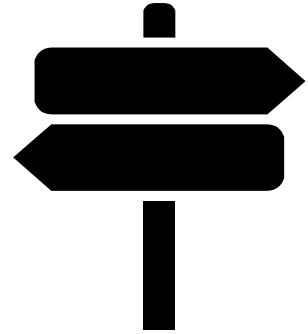


**FINNISH
METEOROLOGICAL
INSTITUTE**

OceanPredict'19

Halifax, NS, Canada, 6-10.5.2019

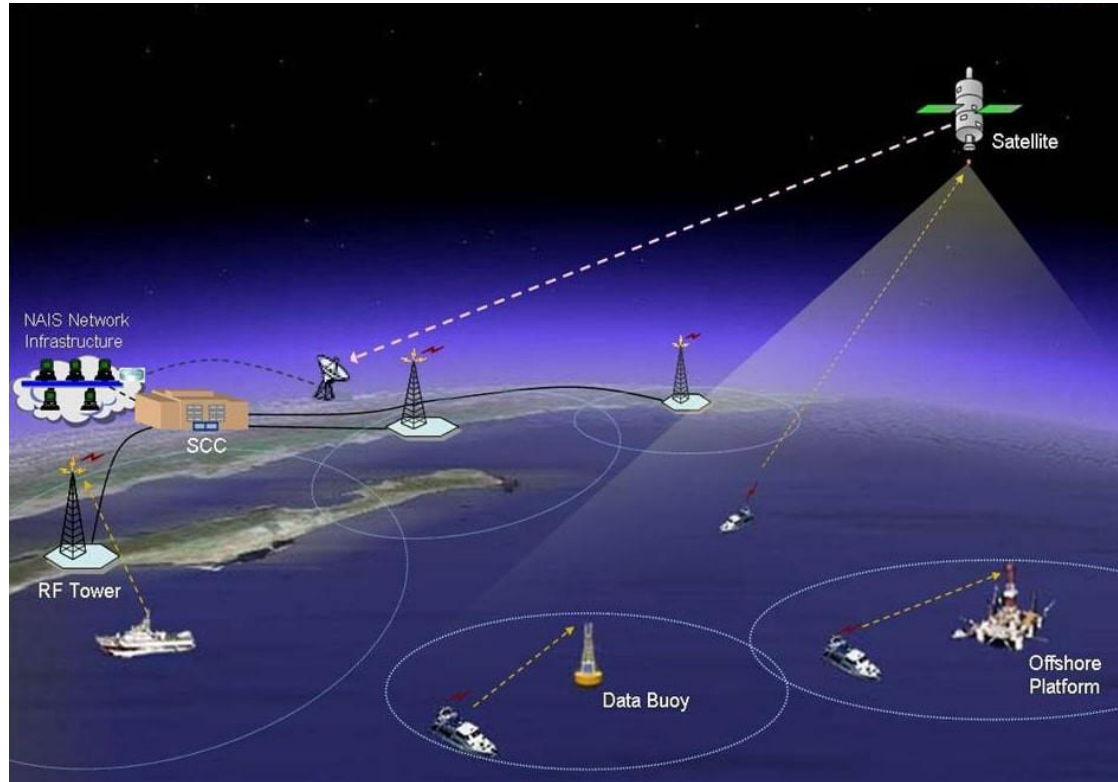
Presentation outline



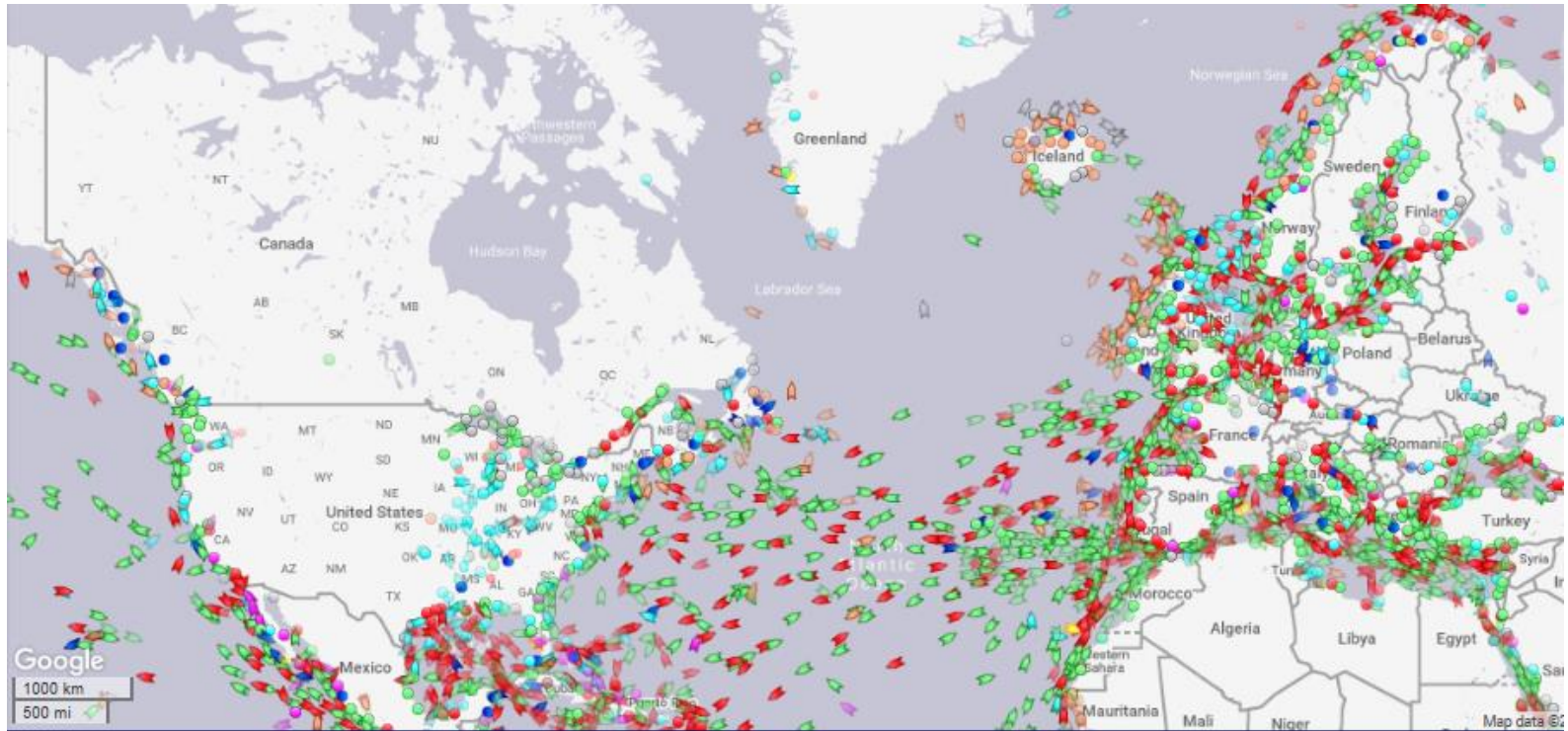
- AIS data as basis for understanding maritime traffic
- Trends in using AIS data
- Big maritime data: AIS data integration
- Developments and applications: examples

AIS data for understanding maritime traffic

Automatic Identification System: technology



AIS data for understanding maritime traffic



Trends in using AIS data

Areas of application

ENVIRONMENT

Fishing
management

Oil spill
monitoring

Ship noise
pollution

Species at risk

SAFETY

Risk analysis

Traffic
simulation

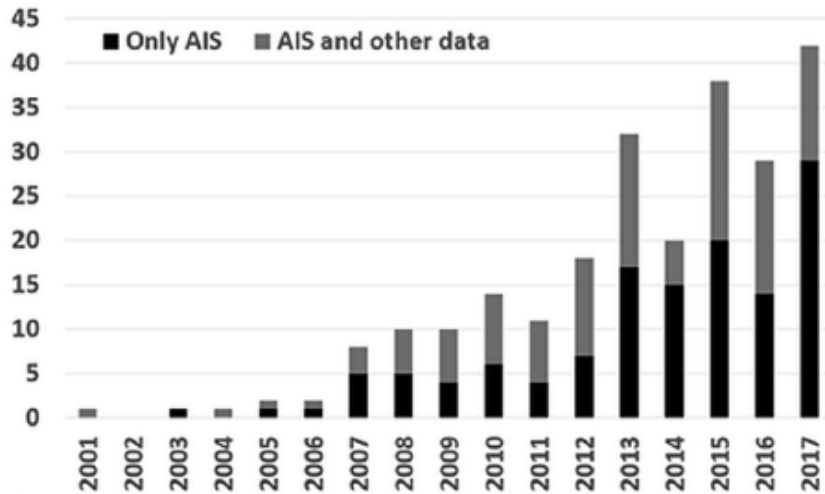
Small craft
safety

SECURITY

Domain
awareness

Counter-piracy
operations

Trends in academic publishing

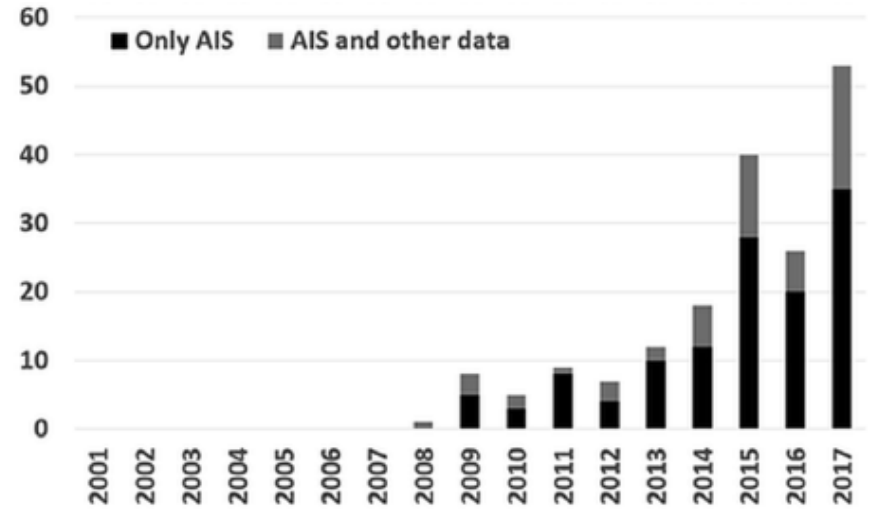


Operation-focused applications

Navigation

Domain awareness

...



Policy-focused applications

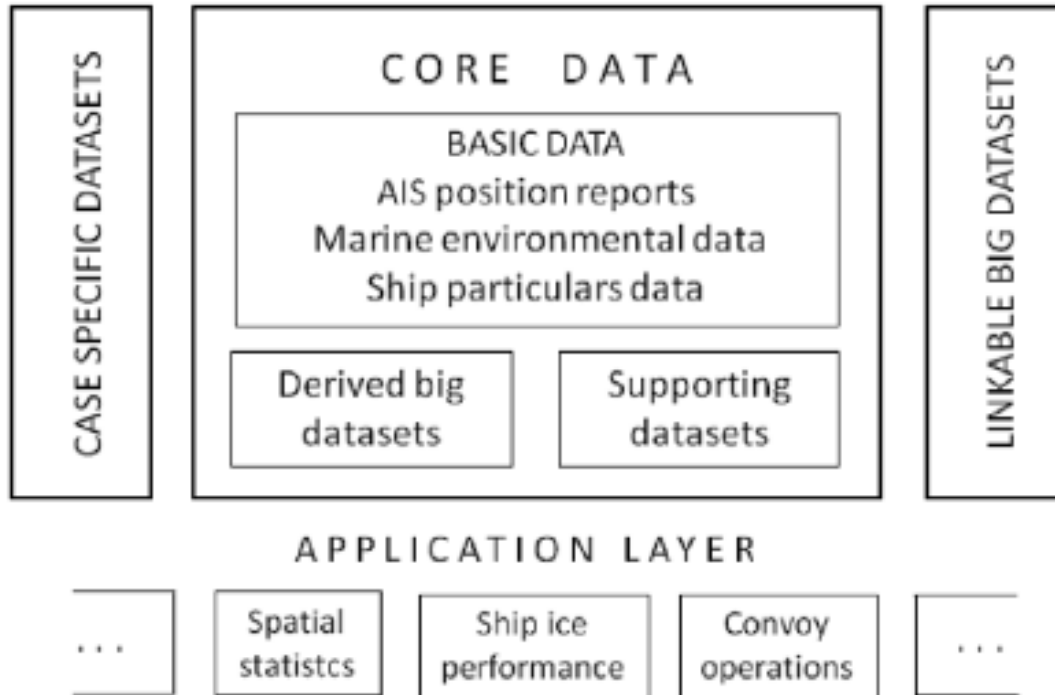
Maritime spatial planning

Pollution impacts

...

Big maritime data: AIS data integration

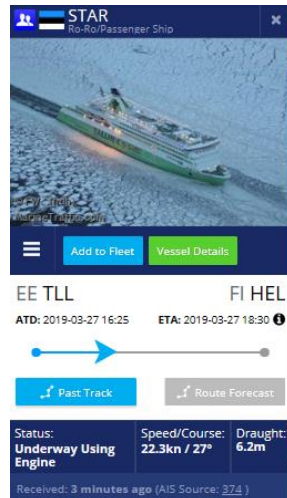
AIS database: layout



AIS database

AIS data

- Full update rate
- Northern Baltic Sea
- 5.7 billion messages
- Terrestrial stations
- 2007-2016
- Coverage ca. 70%

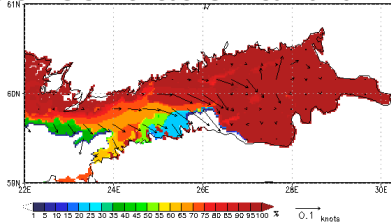


Data field	Unit	Explanation
MMSI number	[-]	A 9-digit code uniquely identifying a vessel
Time stamp	[s]	Time at which the message is recorded, format: yyyy-mm-dd hh:mm:ss
Position	[-]	Longitude and latitude of transmitted message, in WGS-84 coordinate system
Ship type	[-]	A 2-digit code identifying the type of vessel, see USCG (2012)
Ship length and width	[m]	Dimensions from bow to stern and side to side, see USCG (2012)
Ship speed	[kn]	Speed over ground
Ship course	[°]	Course over ground, relative to true north. This is the direction in which the ship is moving.
Ship heading	[°]	Direction in which the bow of the ship is pointing, relative to true north

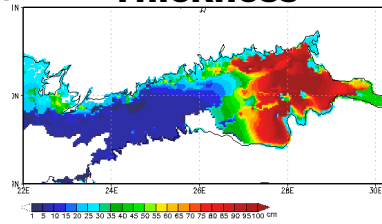
AIS database

Sea ice: Helsinki Multicategory Sea Ice Model (HELMI)

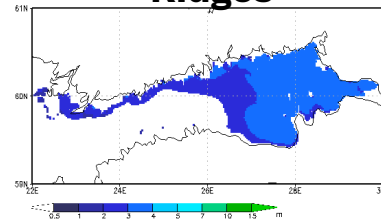
Concentration and drift



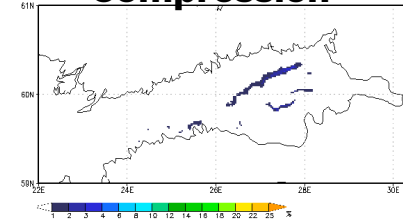
Thickness



Ridges



Compression



Ice chart concentrations

Pack ice concentration 0–99%

Fast ice (concentration 100%)

Ice chart thicknesses

Minimum ice thickness cm

Maximum ice thickness cm

Average ice thickness cm

Ice chart degree of ridging

0 Level ice

1 Rafted ice

2 Slightly ridged ice

3 Ridged ice

4 Heavily ridged ice

5 Brush barrier (windrow)

HELMI level ice categories

Category 1 thickness, concentration and snow thickness on ice

Category 2 thickness, concentration and snow thickness on ice

Category 3 thickness, concentration and snow thickness on ice

Category 4 thickness, concentration and snow thickness on ice

Category 5 thickness, concentration and snow thickness on ice

HELMI deformed ice categories

Rafted ice thickness

Rafted ice concentration

Ridged ice thickness

Ridged ice concentration

HELMI dynamical variables

Ice velocity u-component

Ice velocity v-component

Ice pressure parameter x

Ice pressure parameter y

HELMI forcing data

Wind speed u-component

Wind speed v-component

Air temperature

Sea surface temperature

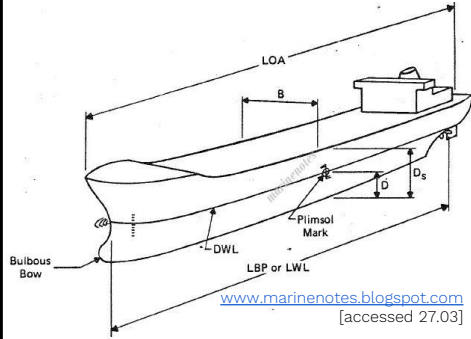
HELMI derived variables

Total concentration

Average thickness

AIS database

Ship data



Vessel particulars

- | | |
|---|---|
| 1 MMSI number | 14 Main engine RPM (revolutions per minute) |
| 2 IMO number | 15 Number of engines |
| 3 GRT (Gross Registered Tonnage) | 16 Build year |
| 4 DWT (Deadweight Tonnage) | 17 Ship type numeral (Table 4) |
| 5 Length Overall | 18 Ice Class numeral |
| 6 Length Between Perpendiculars | 0 Not given |
| 7 Breadth | 1 IA Super |
| 8 Draught | 2 IA |
| 9 Bulb present? | 3 IB |
| 10 Number of propellers | 4 IC |
| 11 Propeller RPM (revolutions per minute) | 5 II |
| 12 Main engine power | 6 'Ice strengthened' |
| 13 Main engine stroke number | 7 'Icebreaking' |



Vessel types

- | | |
|--|---|
| 1 BARGE Self-propelled barge | 15 ROPAX Ro-ro ship that can carry passengers |
| 2 BULK General Bulk Carrier | 16 RORO General ro-ro ship |
| 3 CONT General container ship | 17 S Supply vessel |
| 4 DREDGE General dredge | 18 S&R Salvage and rescue vessel |
| 5 FERRY General ferry | 19 SAIL Sailing vessel |
| 6 FISH General fishing vessel | 20 TUG General tug |
| 7 GC General cargo, multipurpose carrier | 21 T_CHEM Chemical Tanker |
| 8 IB Icebreaker | 22 T_CRD Crude oil tanker |
| 9 OILRIG Drilling rig | 23 T_LNG LNG Tanker |
| 10 OTHER Type not specified | 24 T_LPG LPG Tanker |
| 11 PAS Passenger ship, minimum capacity 12 | 25 T_PROD Products Tanker |
| 12 PAS_CR Passenger cruise ship | 26 V Vehicles carrier |
| 13 POLICE Patrol or non-armed naval vessels, | 27 YACHT Usually a leisure boat |
| 14 RC Refrigerated cargo ship | |

AIS database

Derived and supporting datasets

■ Derived datasets

Calculated from basic data due to being time-consuming

- Spatio-temporal adjacency matrix
(to determine independent and assisted navigation)
- Set of connected ships
(to determine vessel groups)

■ Supporting datasets

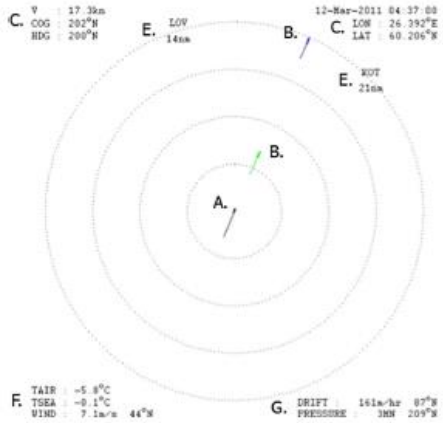
Ad-hoc linkable datasets for specific applications

- Descriptors of specific operations
- Accident data

AIS database

Supporting datasets: Operations description

Video construction



HELLO
MY NAME IS
EXPERT



Operations analysis

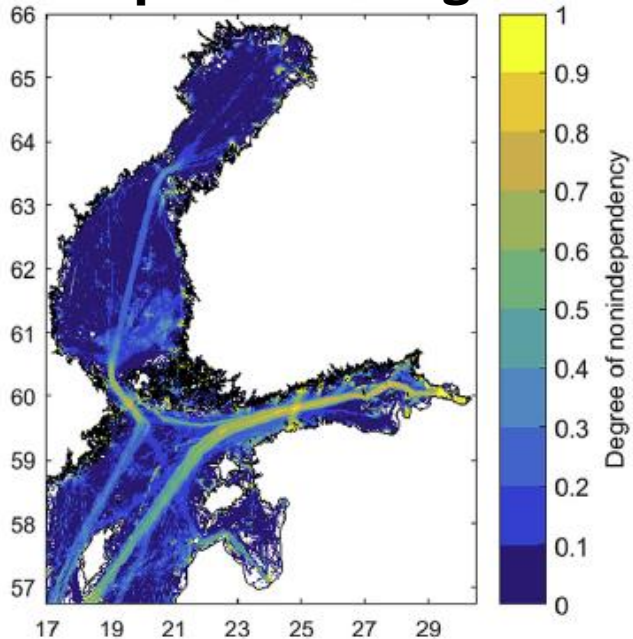
Operation	Time (top: hour, below: time interval in minutes)														
	10										11				
	6	12	18	24	30	36	42	48	54	60	6	12	18	24	30
Escorting															
Convoy															
Double convoy															
Breaking loose															
Towing	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Meeting	x	x	x	x							x	x	x	x	x
Begin/end assistance															
Exchange											x				
Connect/disconnect tow															
Not engaged															x

Developments and applications: examples

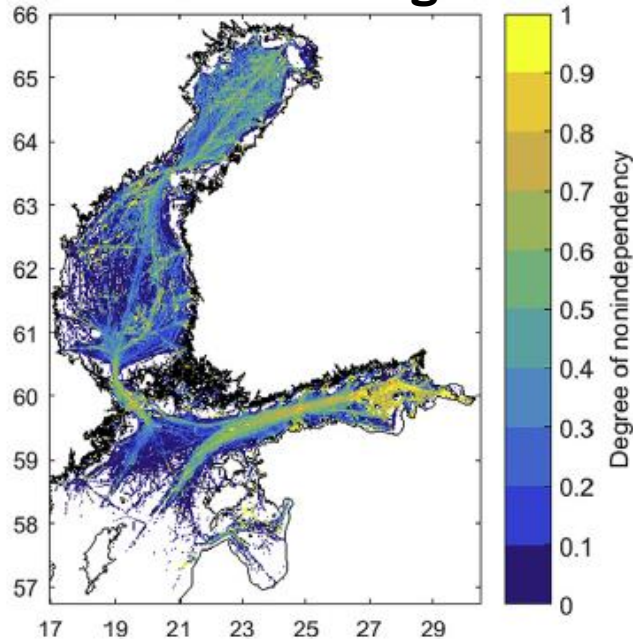
Application: data analysis

Spatial traffic statistics

Independent navigation



Assisted navigation



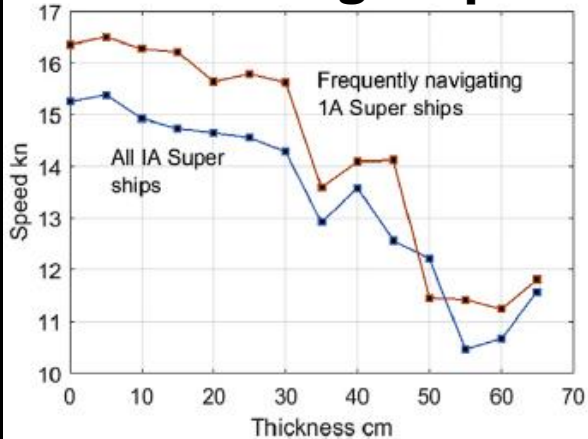
USE

Icebreaker
operability and
planning

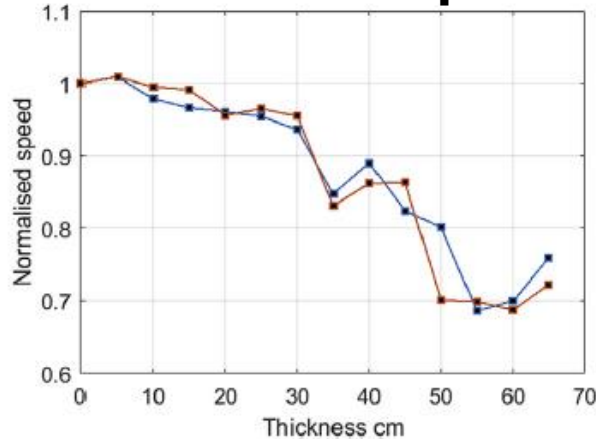
Application: data analysis

Navigation speed in ice

Fleet-averaged speed



Normalized speed



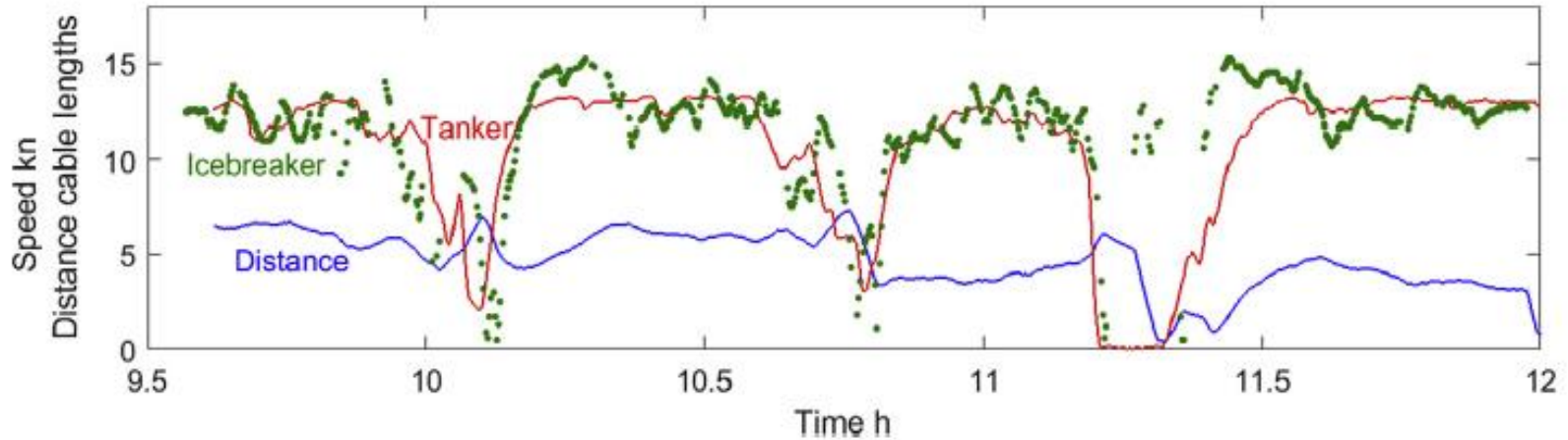
USE

Trafficability
analysis

Ship routing

Application: data analysis

Icebreaker assistance (1)

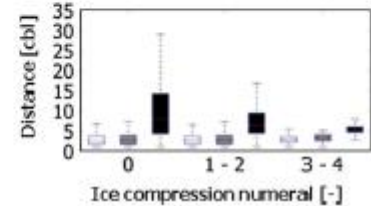
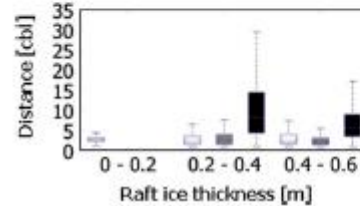
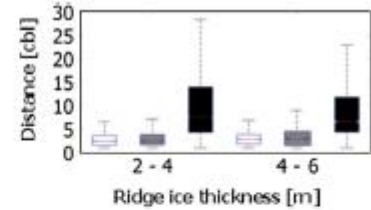
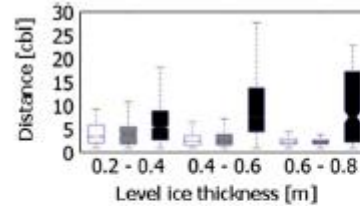
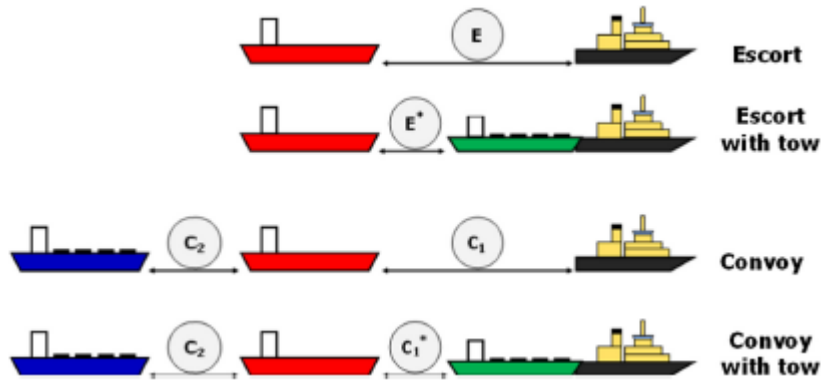


USE

Operational
understanding

Application: data analysis

Icebreaker assistance (2)

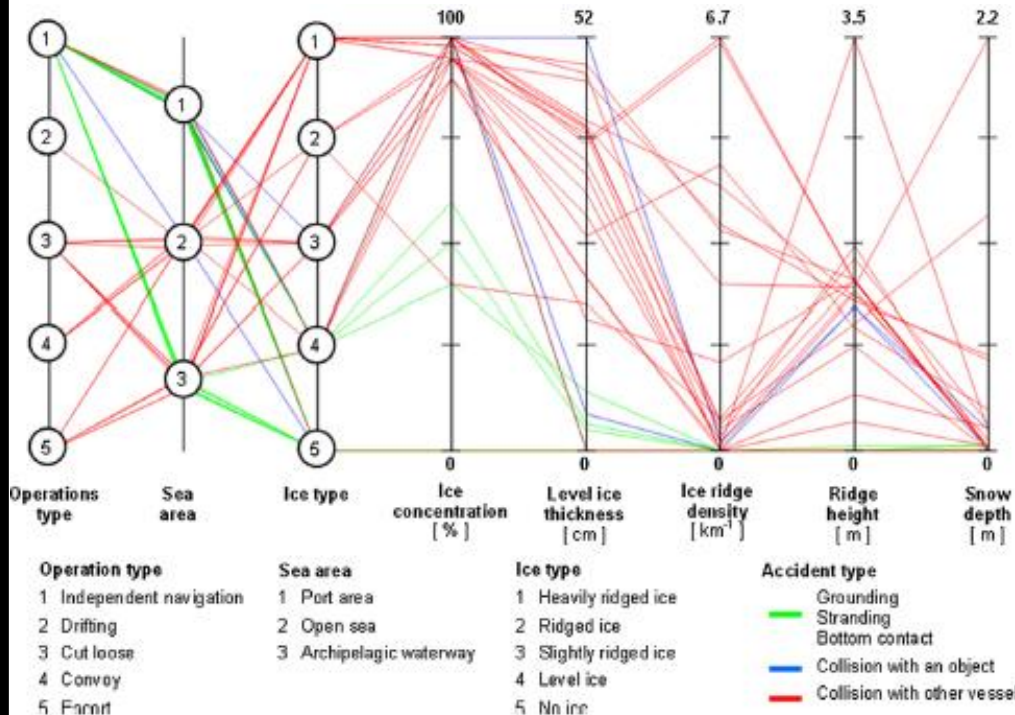


USE

Understanding safe
convoy distance

Application: data analysis

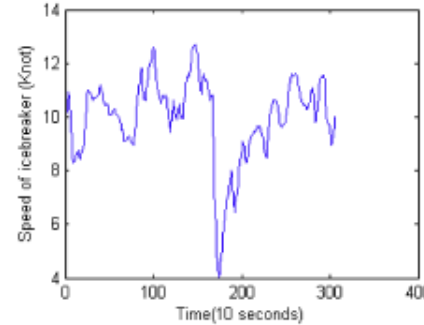
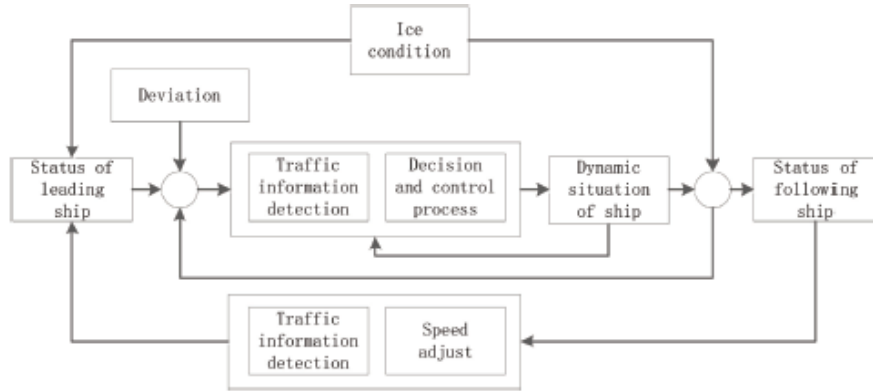
Accident analysis



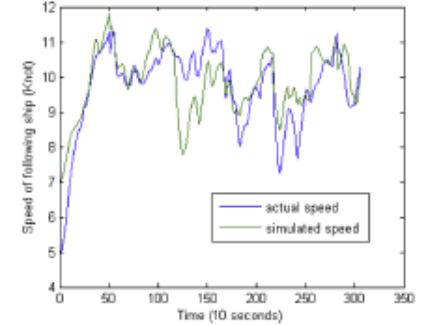
USE

Understanding patterns under which accidents occur

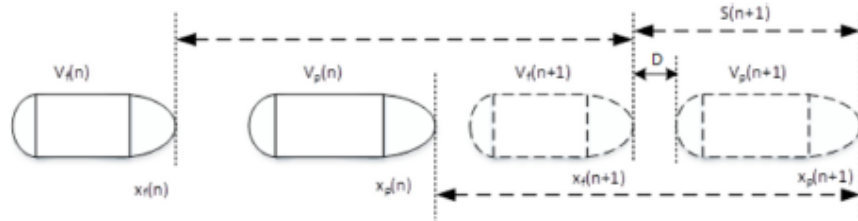
Application: modeling Icebreaker convoy model



(a) Speed of ice breaker



(b) Speed of the assisted ship



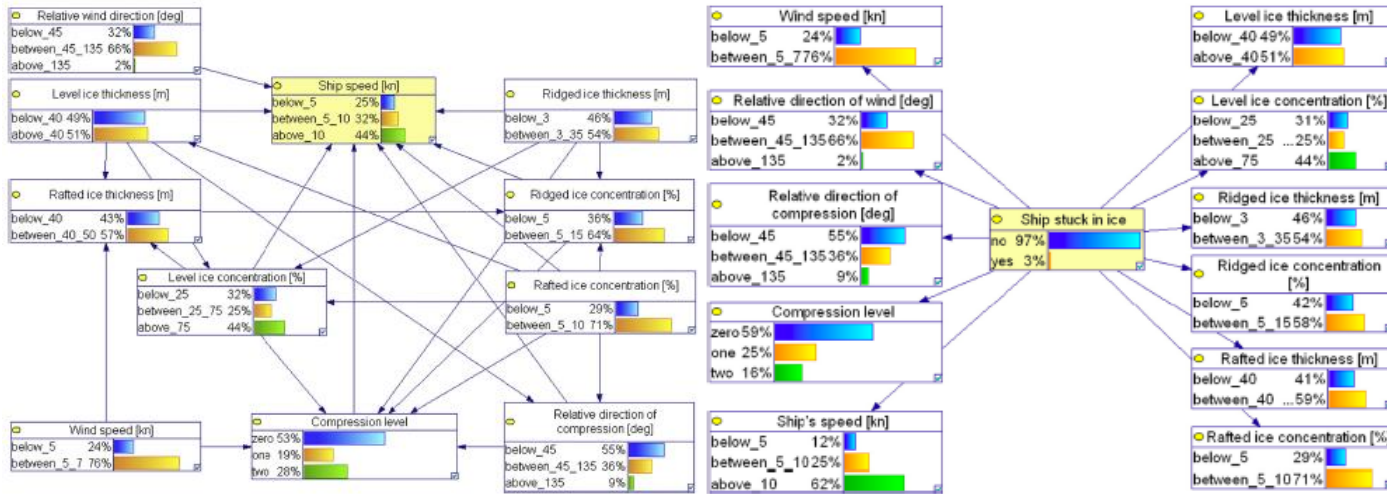
USE

Realistic model for
convoy operations, for
simulator training

Application: modeling Ship performance model in ice (independent navigation)

**Data-driven model
for ship speed**

**Data-driven model
for ship beset in ice**



USE

Trafficability analysis

Ship routing

Questions? Comments?

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