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

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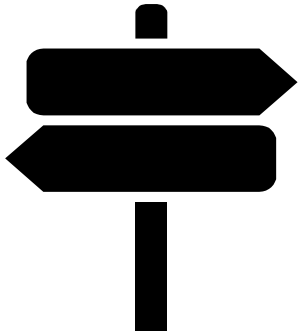
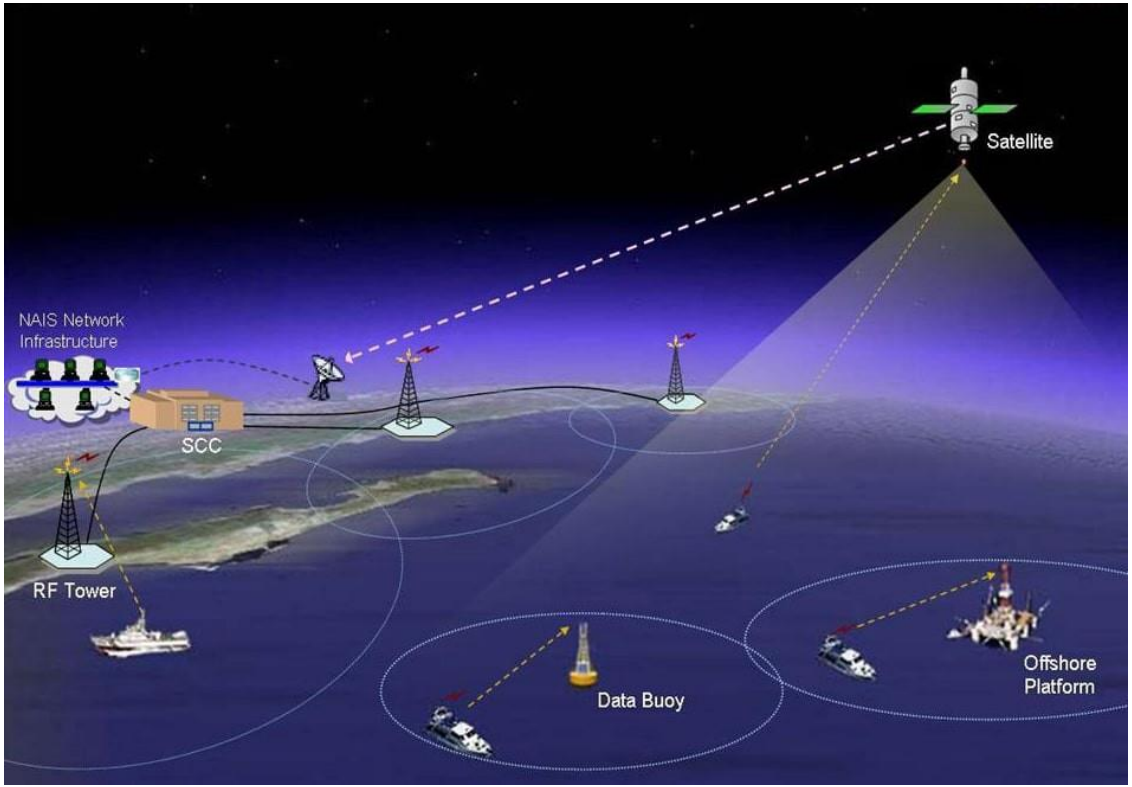
Presentation outline



- 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



Source: http://sea-eye.org [accessed 26.03.2019]

AIS data for understanding maritime traffic

Source: http://www.marinetraffic.com [accessed 27.03.2019]

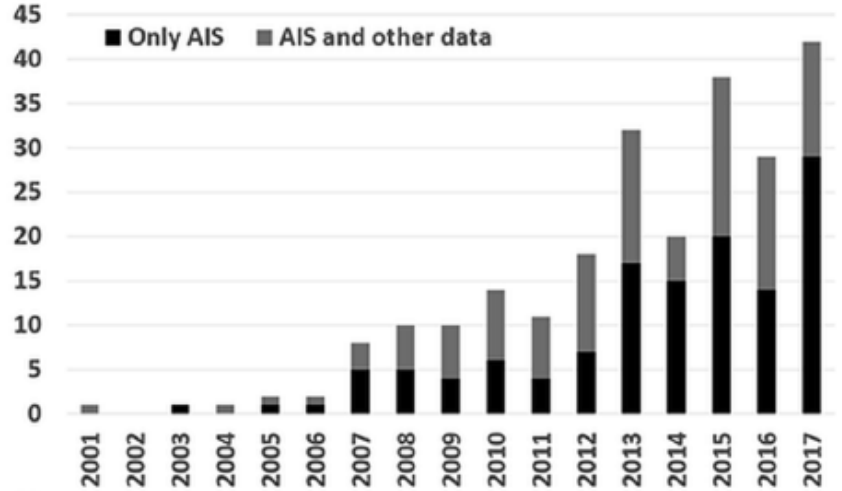
Trends in using AIS data

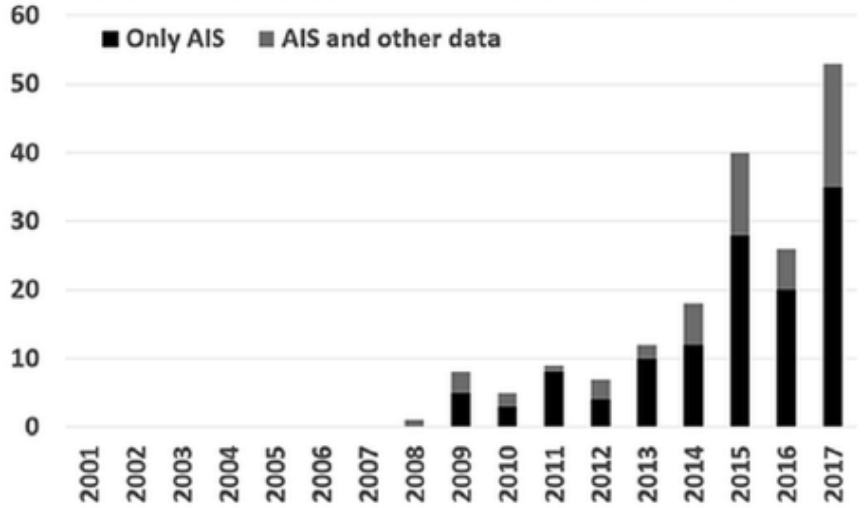
Areas of application

ENVIRONMENT	SAFETY	SECURITY
Fishing management	Risk analysis	Domain awareness
Oil spill monitoring	Traffic simulation	Counter-piracy operations
Ship noise pollution	Small craft safety	
Species at risk		

Fournier M., Hilliard R.C., Rezaee S., Pelot R. 2018. WMU Journal of Maritime Affairs 17:311-345.

Trends in academic publishing





Operation-focused applications

Navigation	Domain awareness	…

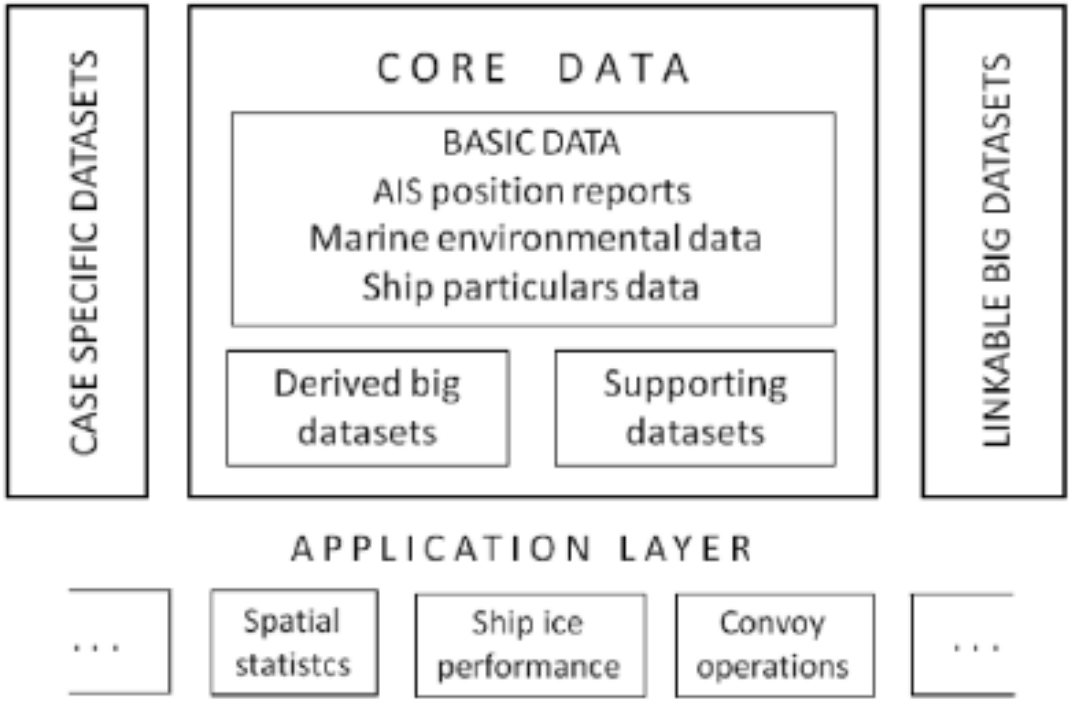
Policy-focused applications

Maritime spatial planning	Pollution impacts	…

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

Big maritime data: AIS data integration

AIS database: layout

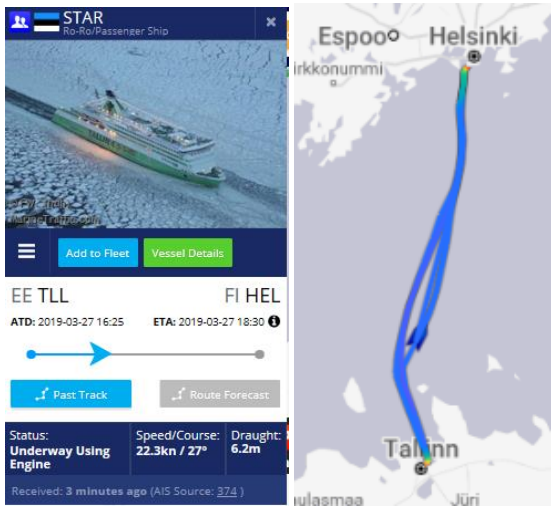


Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

AIS database

AIS data

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



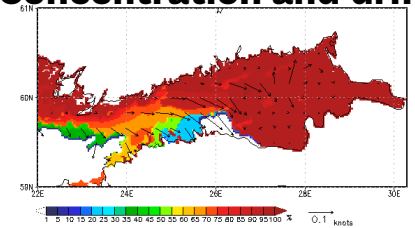
Data field	Unit	Explanation
MMSI number	[–]	A 9-digit code uniquely identifying a vessel
Time stamp	[s]	Time at which the message is recorded, format: yyyy-mm-dd hh:mm:ss
Position	[–]	Longitude and latitude of transmitted message, in WGS-84 coordinate system
Ship type	[–]	A 2-digit code identifying the 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

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

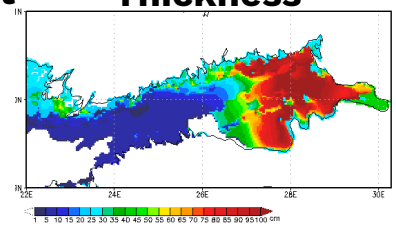
AIS database

Sea ice: Helsinki Multicategory Sea Ice Model (HELMI)

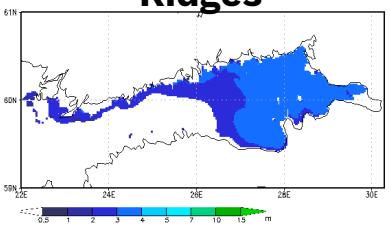
Concentration and drift



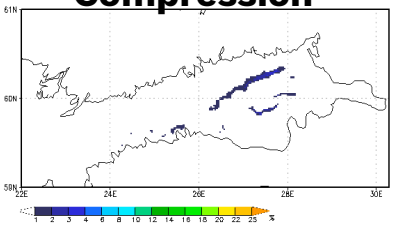
Thickness



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 Brash 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

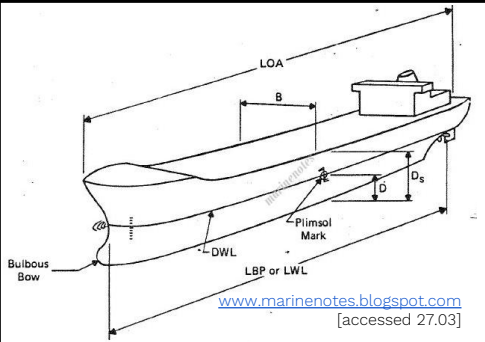
HELMI forcing data
- Wind speed u-component
- Wind speed v-component
- Air temperature
- Sea surface temperature

HELMI derived variables
- Total concentration
- Average thickness

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

AIS database

Ship data



www.marinenotes.blogspot.com [accessed 27.03]

www.arctia.fi [accessed 27.03]

www.tallinksilja.com [accessed 27.03]

www.vesselfinder.com [accessed 27.03]

Vessel particulars

1 MMSI number

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

Vessel types

1 BARGE Self-propelled barge

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

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

AIS database

Derived and supporting datasets

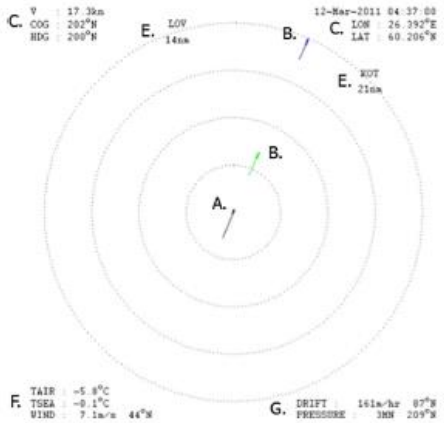
- **Derived datasets**
  Calculated from basic data due to being time-consuming
  - Spatio-temporal adjacency matrix
    (to determine independent and assisted navigation)
  - Set of connected ships
    (to determine vessel groups)
- **Supporting datasets**
  Ad-hoc linkable datasets for specific applications
  - Descriptors of specific operations
  - Accident data

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

AIS database

Supporting datasets: Operations description

Video construction



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		x	x	x	x	x	x	x	x	x	x				
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		x									x				
Exchange															
Connect/disconnect tow															x
Not engaged															

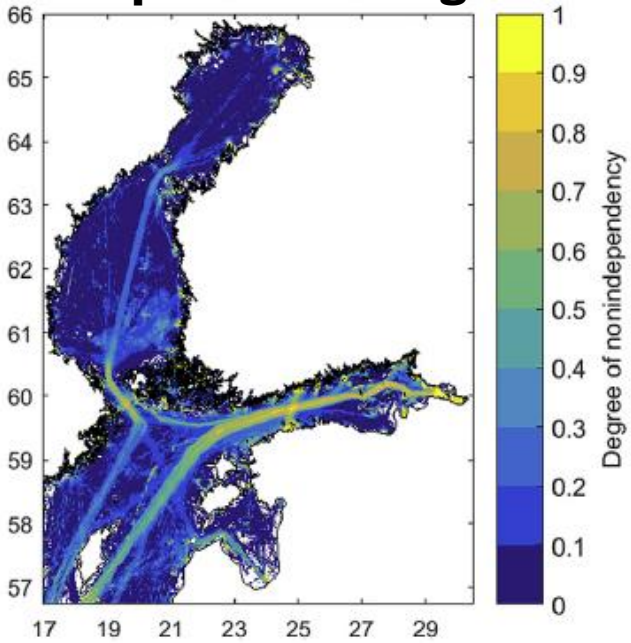
Goerlandt F., Montewka J., Zhang W., Kujala P. 2017. Safety Science 95:198-209.

Developments and applications: examples

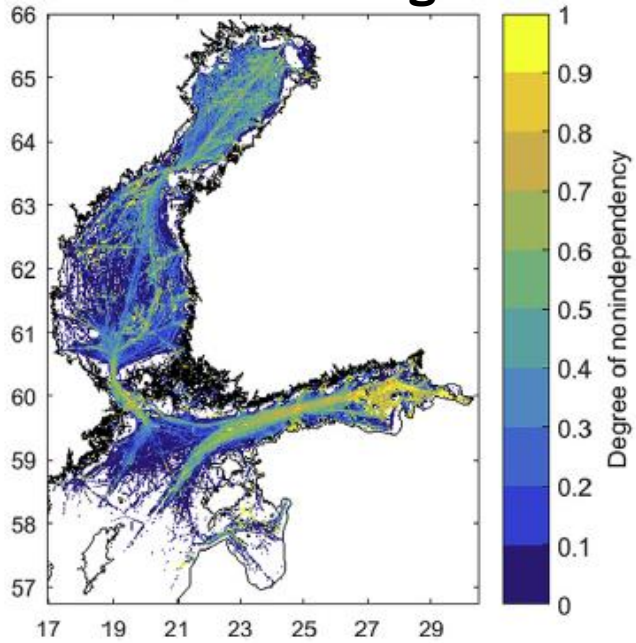
Application: data analysis

Spatial traffic statistics

Independent navigation



Assisted navigation



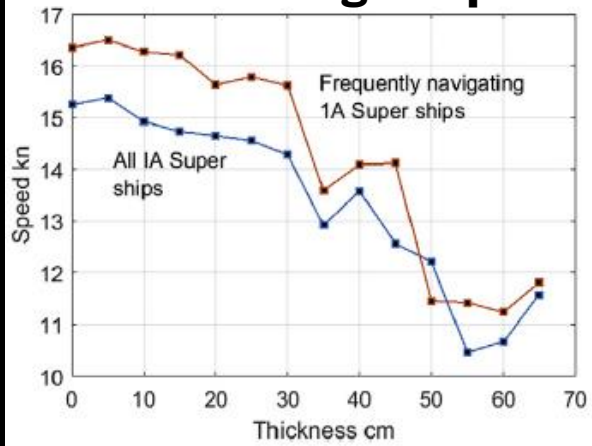
USE
Icebreaker operability and planning

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

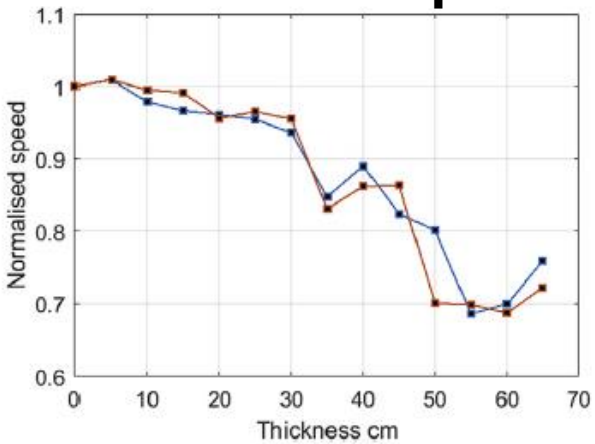
Application: data analysis

Navigation speed in ice

Fleet-averaged speed



Normalized speed

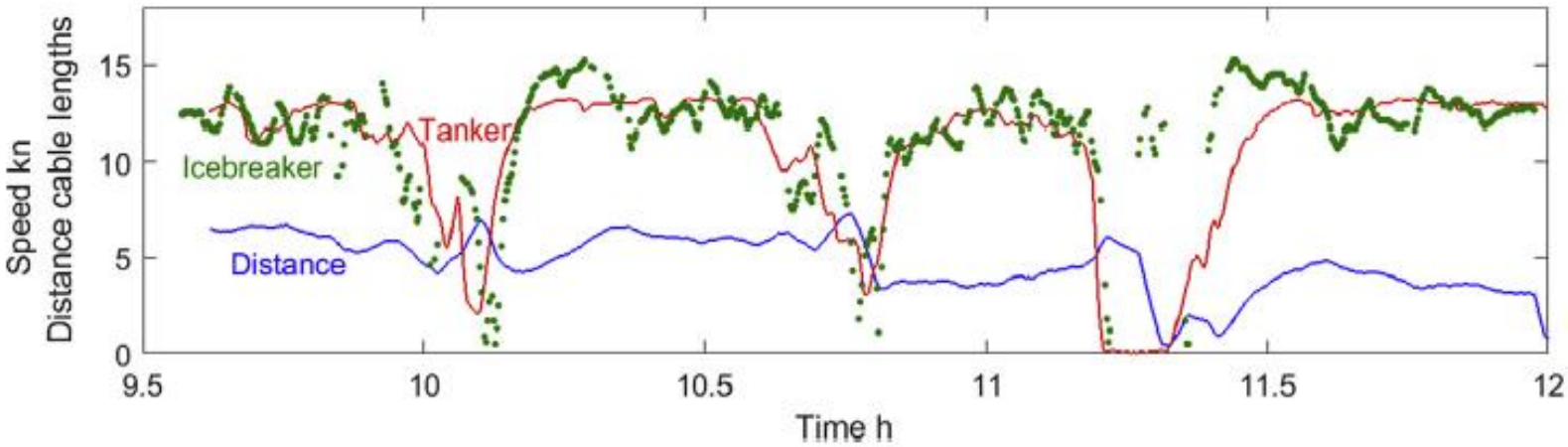


USE
Trafficability analysis
Ship routing

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

Application: data analysis

Icebreaker assistance (1)

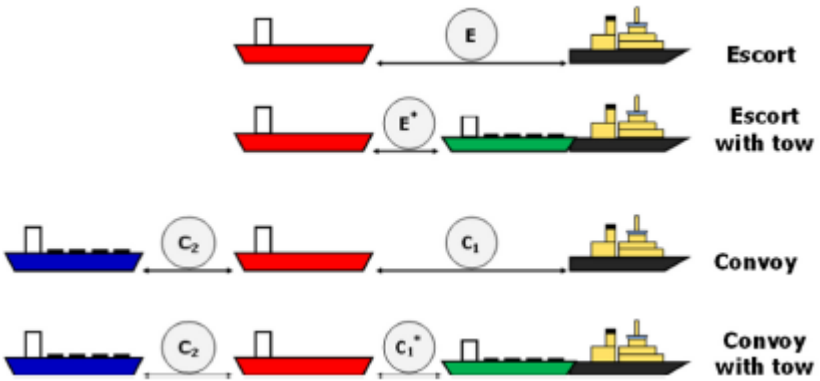


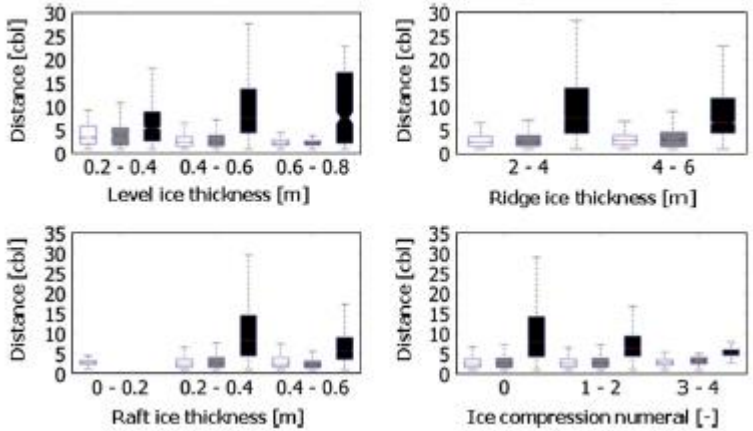
USE
Operational understanding

Lensu M., Goerlandt F. 2019. Marine Policy 104:53-65.

Application: data analysis

Icebreaker assistance (2)



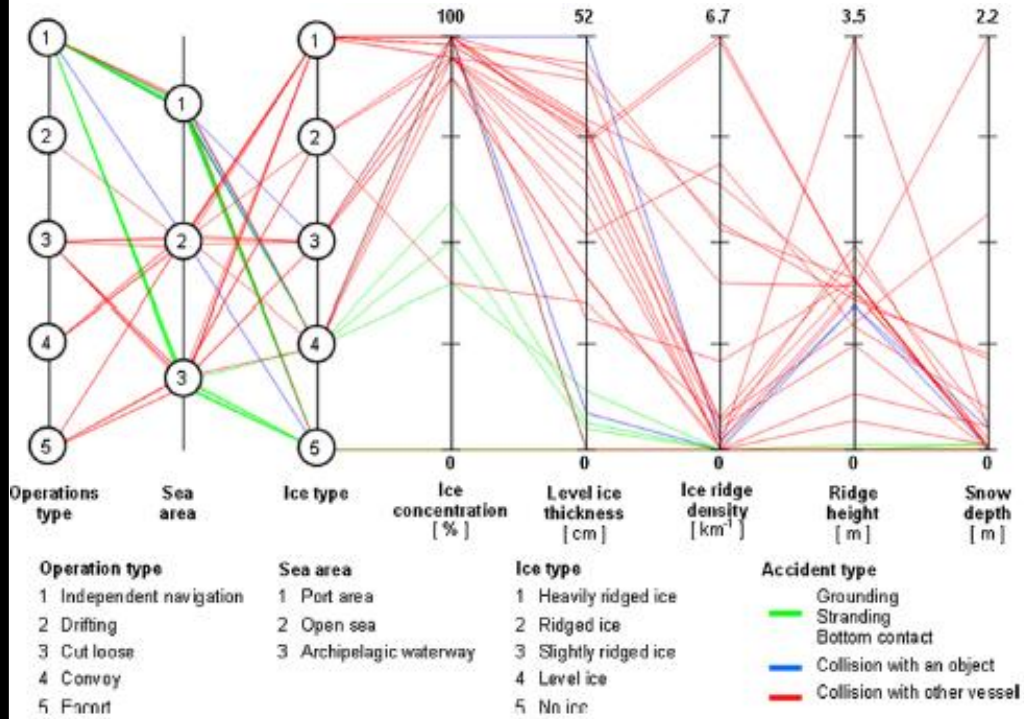


USE
Understanding safe convoy distance

Goerlandt F., Montewka J., Zhang W., Kujala P. 2017. Safety Science 95:198-209.

Application: data analysis

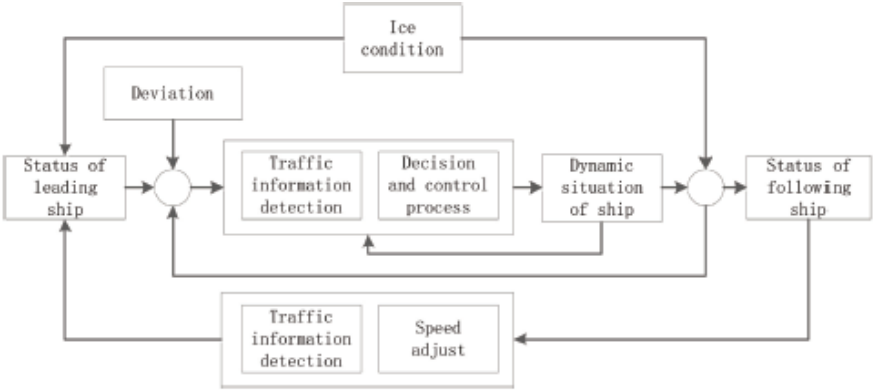
Accident analysis

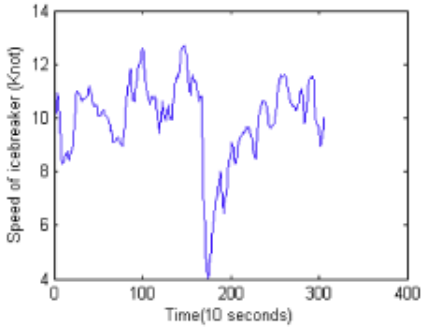


USE
Understanding patterns under which accidents occur

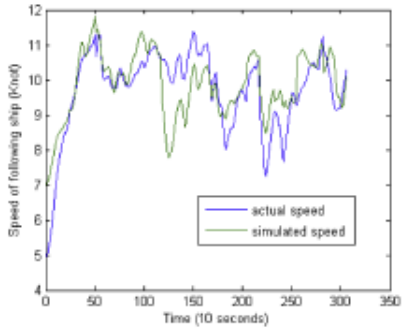
Goerlandt F., Goite H., Valdez Banda O.A., Höglund A., Ahonen-Rainio P., Lensu M. 2017. Safety Science 92:66-84.

Application: modeling
Icebreaker convoy model

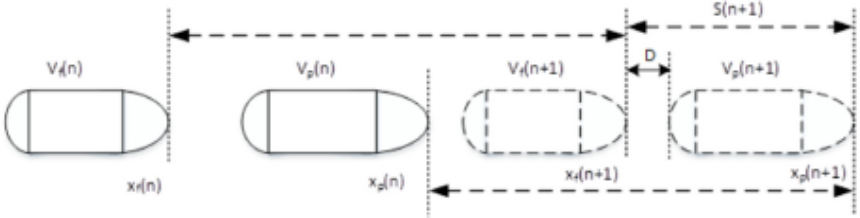




(a) Speed of ice breaker



(b) Speed of the assisted ship



USE
Realistic model for convoy operations, for simulator training

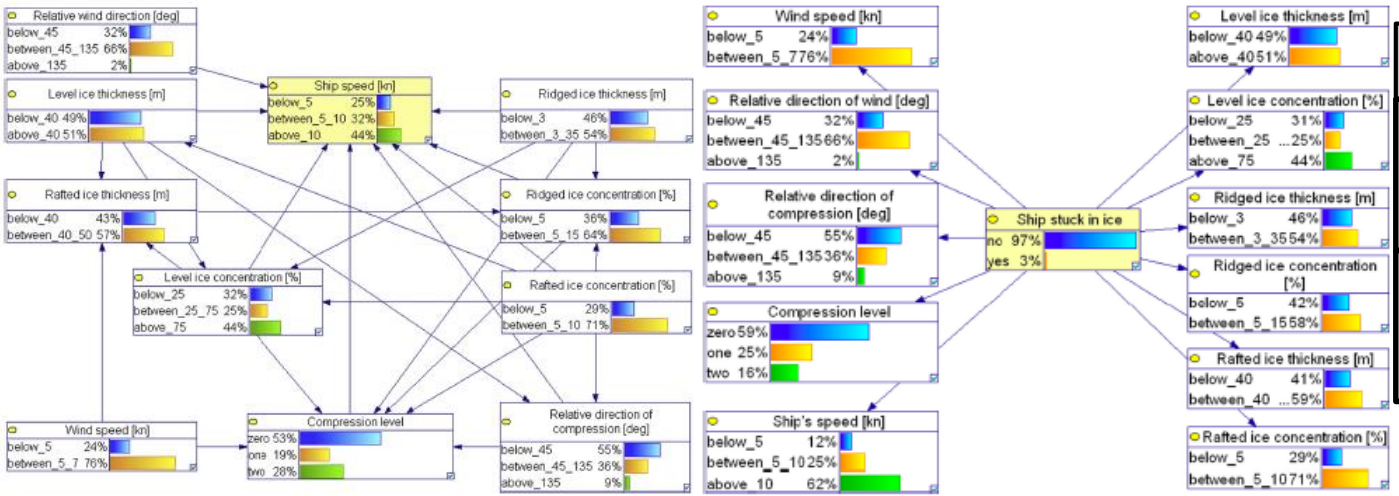
Zhang W., Goerlandt F., Kujala P., Qi Y. 2018. Ocean Engineering 167:317-333.

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

Montewka J., Goerlandt F., Kujala P., Lensu M. 2015. Cold Regions Science and Technology 112:14-28.

Questions?
Comments?

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