MODELLING OF A SEVERE WINTER

Co-financed by the European Union
Connecting Europe Facility

Background

The first EU TEN-T co-financed “Winter Navigation of the Motorway of the Sea” (WINMOS) Action was performed between 2012 and 2015. “Winter Navigation of the Motorways of the Sea II” (WINMOS II) Action started in February 2016 and will continue till 2019. The Action is co-financed by EU Connecting Europe Facility (CEF) programme.

Development of a simulation model of the winter navigation system performance started during WINMOS (I) Action. The objective was to assess icebreaking capacity needed in the future based on current information about the icebreaking fleet and merchant vessel fleet together with predictions of changes in the operating environment, i.e. fuel prices, traffic intensity, SECA directive and future merchant fleets’ independent icegoing capability due to EEDI regulations etc.

A simulation model was created with possibilities to adjust factors and parameters related to transport volumes and frequencies to and from harbours, merchant vessels’ size and independent ice going capability, ice conditions as well as number and capability of icebreakers.

Further development of the winter navigation model is sub-activity 8.1 in WINMOS II under Activity 8 “Study on adequacy of icebreaking capacity and level of service in the Baltic Sea during severe winters”. The simulation model was further developed and a scenario of a very severe winter was studied. The model can be used to study the adequacy of icebreaking capacity and level of service in the Baltic Sea especially during severe winters. Statistically, severe winters occur once or twice in a decade. The last winter classified as a severe winter was in 2010 - 2011 with maximum ice extent of 309 000 km2. Since then the winters have been classified as normal or mild. During a very severe winter even the Danish straights freeze. The consequences and needed measures and procedures to minimize the harm of a severe winter are naturally of greater scale than for a normal winter.

Simulation model

Working principles of the model

The model is used by constructing a fairway network that resembles the winter traffic system of interest. The network is constructed by using two different network building blocks: (1) a block resembling a fairway section between two points, and (2) a junction block, with three outgoing legs of any length and shape. A port can be assigned to the end of a block leg.

The number of icebreakers in the system, and the operational areas of the individual icebreakers can easily be adjusted in the model.

As default, one icebreaker is assigned to each building block and the icebreaker is constrained by the borders between the building blocks. However, the operational area can be expanded by assigning multiple blocks to the same icebreaker, so that there is only one icebreaker in the joined blocks. The total number of icebreakers in the system is indirectly controlled by this block joining procedure. Now the icebreaker is only constrained by the borders between different operational areas. There is also a possibility to assign two icebreakers into one single block, in which the icebreakers are programmed to work optimally between each other, however, this kind of block cannot be expanded into multiple blocks.

The icebreaker makes assistance decisions so that the waiting time of ships in need of assistance is minimized. It only considers the ships that will need assistance somewhere within the operational area. The icebreaker receives information of incoming ships from neighbouring operational areas in advance so that ships, which have not yet arrived into the operational area, are also included in the waiting time minimization process. There is an adjustable parameter, which determines the amount of hours the icebreaker can see into the future.

Changing the fairway network within a simulation run

The fairway network needs to be changed if the structure of modelled system changes within the simulation period. This could mean for example adding or removing an icebreaker, modifying the operational areas, or modifying the structure of the fairway network. The model can be pre-set to change within the simulation run without losing much or any information which would be lost, if the simulation would be interrupted every time a change should be made.

Ice conditions (Input)

The start and end coordinate points (long-lat.) of each fairway section must be inputted into the program. The program then automatically reads the ice-data (from an ice-data grid made available to the program) into each fairway section.

Ship ice going capabilities (Input)

HV-curves (calculated information of a ships speed in different ice conditions and thickness) for different ship types are made available to the program.

Ship time-schedule and destinations (Input)

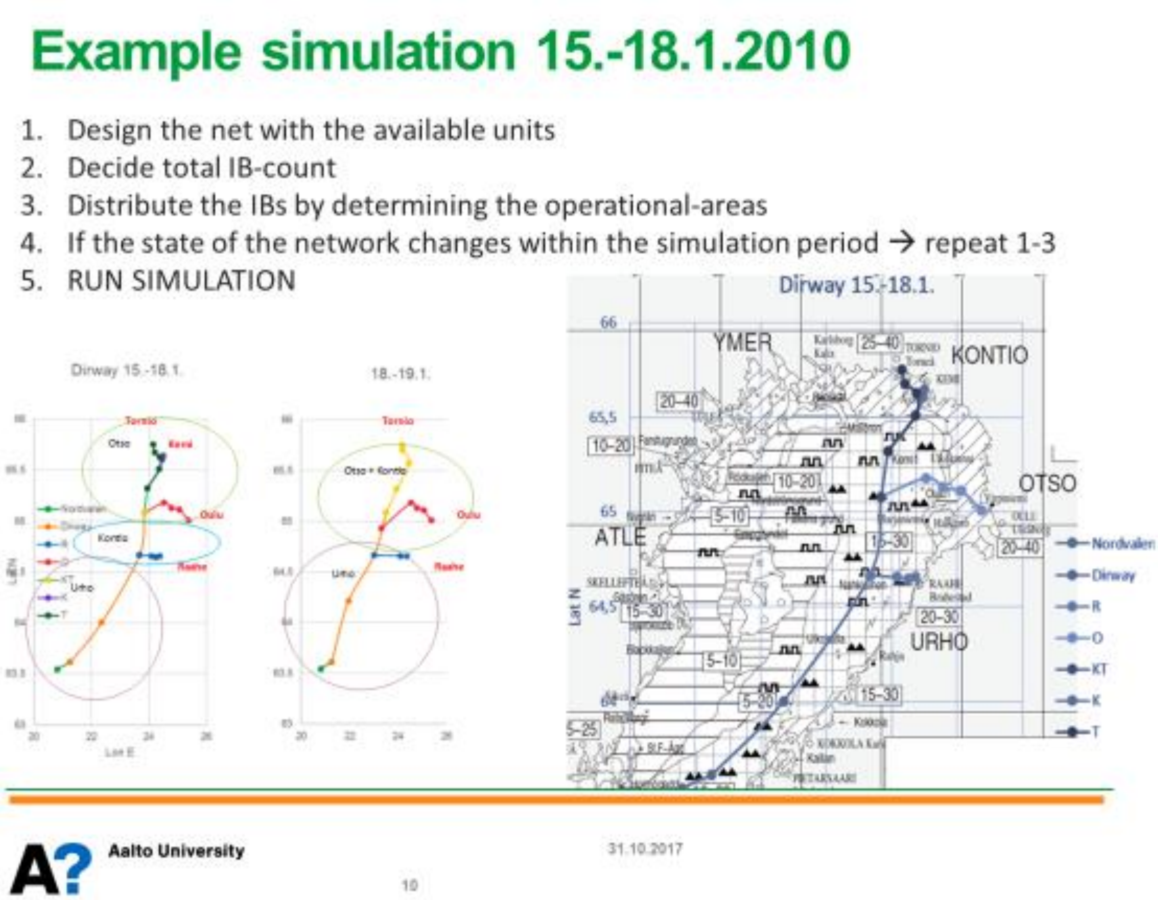
The time when each ship enters the network, and from where in the network they enter and their destinations within the network, and the estimated durations of their port visits, are all inputted into the program.

Model Output

The model keeps track of every event of the simulation run, i.e. all merchant ship's stop positions (where they needed assistance) and times, and how long they waited for the icebreaker to arrive.

Assistance events are also tracked: length, average speed and position of assistance. Type of assistance: assistance at distance or towing.

Icebreaker power usage (100/80/60%) (available only for transitions when it did not assist)



More details of the model can be found here:

http://repository.am.szczecin.pl/handle/123456789/752?show=full

Note that the information behind the link is two years old and the model has been updated a lot since then, but the basic principles remain the same.

Modelling of severe winter

The data selected to be used for the severe winter model was 15 January – 15 February 2010. This period was considered to be a good example of a hard winter for the area in question. The data includes vessels' AIS data, port data, vessels' arrival and departure times and dates, ice information, how the vessels perform in ice, icebreakers' operational areas etc. The model is based on certain assumptions related to behaviour of both icebreakers and merchant vessels and somewhat simplified from the reality.

The modelled area here is the Bay of Bothnia. The results of the model are not directly scalable to the whole Baltic Sea but they can, however, be used to build scenarios for the whole Baltic Sea area.

Utilisation of the model

The simulation model can be used to analyse traffic flows in the Finnish-Swedish winter navigation system. The simulation model collects data from each simulation run. The outputs include e.g. waiting times for merchant vessels and icebreakers' travel time, power and fuel consumption, and towing information. The information received from the simulation runs can be used in the financial model produced during WINMOS (1) to estimate and calculate total costs of winter navigation and to produce different scenarios and possible cost development.

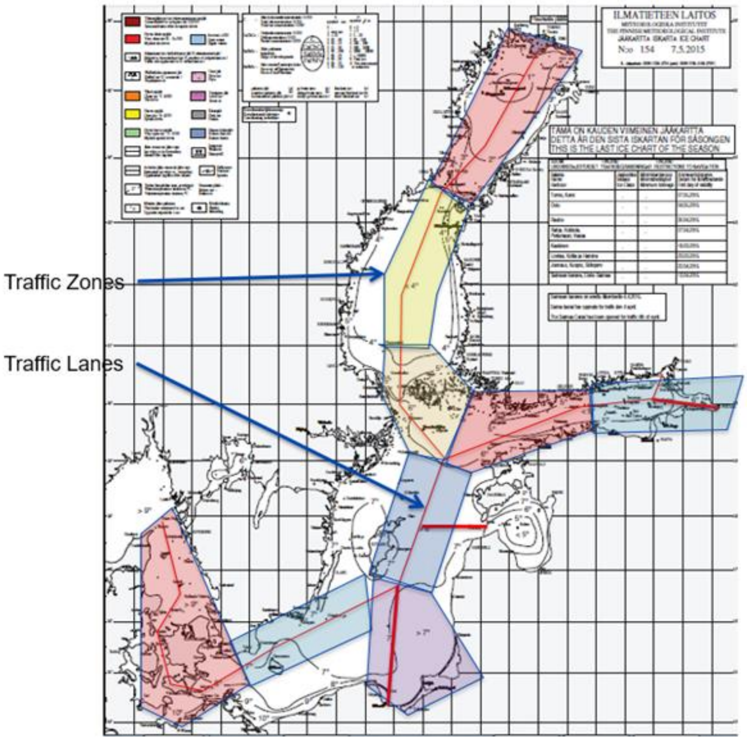
Changing the parameters in the model will affect the results and outputs. This allows the user to investigate how different parameters of the system affect the results and estimate effects on the winter navigation system in its entirety. For example changing the inputs by increasing the amount of so called EEDI vessels the model can indicate how the increased amount of assistance time spent on these vessels would affect the winter navigation system cost and the final consumer price of the transported goods.

Contingency plan for severe winter

By using the simulation model and a traffic analysis, a contingency plan has been drawn up for the whole Baltic Sea in case of extremely severe winters. The idea of the plan is to have operational readiness for severe winters in the whole Baltic Sea area and its main goals are safety of shipping and the most effective traffic flow possible in those conditions.

The plan will act as a tool and common guidelines to all Baltic Sea states, coordinating international authority team, icebreakers, VTS centers etc. The IBNet software will most probably be the coordinating tool for authorities and VTS centres in case of a severe winter. Due to the renewal of the software, it can be distributed on laptops also to countries that are not normally using it when winters are normal or mild (e.g. Denmark and Germany).

In the plan, the whole Baltic Sea has been divided into zones, which are all coordinated by one icebreaker. The zone coordinating factors include e.g. traffic volumes, assisted ship types, ice and weather conditions, national logistics interest (security of supply, industry etc.), ice restrictions etc.



Baltic Sea is divided into zones in the contingency plan.

Conclusions

Reduction in fuel consumption and emissions is becoming increasingly important in the marine industry. The Energy Efficiency Design Index (EEDI) is a measure of energy efficiency of ships in transportation so that maximum cargo is transported with minimum fuel consumption and therefore minimal CO_2 emissions. The EEDI regulations force vessel technologies to become more energy efficient over time. Studies have shown that vessels fulfilling EEDI and other increasing environmental requirements will have less ice going performance than older ships with higher engine power. This will probably lead to increased waiting and transport times as well as a decrease in the service level, since the amount of icebreakers is limited.

The simulation model can be used as a tool to create different scenarios with future vessels and make calculations of the service level e.g. during very severe winter in the whole Baltic Sea area to help make strategic decisions that affect the whole winter navigation system.