Voyage optimisation on the shallow waters of the Baltic Sea

The MONALISA project is focusing on efficient, safe and sustainable maritime transport. A Sea Traffic Coordination Centre, similar to that in the aviation sector, will coordinate vessels by offering them fuel-optimised routes. These green routes are calculated using algorithms developed by SSPA, utilising the legacy of knowledge in hydrodynamics and testing thousands of ships, combined with novel optimisation methods. Evaluations were made on real routes, collected from historical AIS data compared with new optimised routes. The potential of a 12% saving was found in a case study on transit traffic through the shallow waters of the Kattegat.

The vessel POUL LØWENØRN in the Great Belt, exchanging routes with the STCC ashore in Gothenburg.

The STCC concept

When a vessel is approaching a sea area under control of a Sea Traffic Coordination Centre (STCC), the captain is offered to send his intended route to the STCC for optimisation. The STCC will make appropriate changes to the route, e.g. insert constraints like a No Go Area. Since SSPA acts as a service provider the route is sent to the SSPA server via the internet. The SSPA service will deliver an optimised route back to the STCC fulfilling the constraints, and desired time of approach (ETA) with the lowest fuel consumption. The STCC will check the route and then send it back to the vessel.

The concept was successfully demonstrated with the vessel POUL LØWENØRN in the Great Belt, communicating with a prototype STCC, which then accesses the server at SSPA.

The SSPA route optimisation routine

The route optimiser is a cloud-based web service that will optimise the route by adding, moving and removing waypoints, ensuring the ETA is still preserved. The route optimiser will also set the optimum speed for each leg in order to minimise fuel consumption. These are the optimisation components:

The geo component

- Includes forecasts and depth data.
- Continually takes into account the shift in time and place of the weather forecast during optimisation.

The ship component

- Calculates the fuel consumption in a 20 m × 20 m resolution grid.
- Calculation depends on wind, waves, currents and depth and the interaction with the hull and propulsion characteristics.

The route component

- Traversing the area from start to finish to determine the most fuel-efficient way.
- Finally it simplifies the route, reducing the number of waypoints and adjusting speed.

The depth information is of course essential for optimising a route with sufficient Under Keel Clearance (UKC), but it is also vital for calculating the increased hull resistance due to the squat effect, which should be considered in shallow waters like the Baltic Sea and many other European waters.

The optimisation kernel was developed together with the Fraunhofer-Chalmers Research Centre for Industrial Mathematics.

Case study of green routes in the Kattegat

To investigate the effect of green routes on the traffic pattern, a study was made of the transiting vessels through the Kattegat based on actual AIS data compared with simulated AIS data from the route optimisation. The following delimitations were set:

- AIS data from one month, January 2012, with about 1,700 vessel movements.
- AIS-class 60-89, i.e. passenger ships, cargo ships and tankers.
- Transiting between the areas: Skaw, Gothenburg, Great Belt or The Sound.
- Vessels must make speed all the time.
- Draught greater than 5.3 m.
- Wind, waves and current set to predominant values for the region.

Geographic scope of the study. The outer boundary is for the current main traffic in the Kattegat. The green zones are used to identify the present main transit traffic through the Kattegat.

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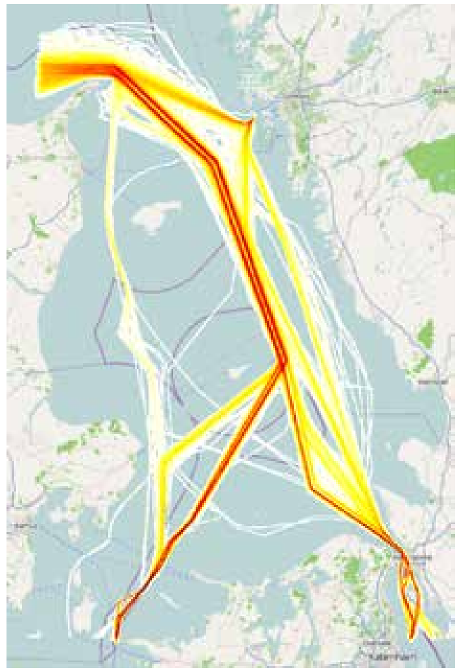

Density plot for the current main transit traffic through the Kattegat. Carried out with the IWRAP risk assessment tool, based on Helcom's AIS data for January 2012. (Recalculated to one year.)

Density plot for the optimised routes. Carried out with the IWRAP risk assessment tool, based on SSPA's simulated AIS traffic data from optimised routes. (Recalculated to one year.)

The optimisation is free to find new routes without considering today's routing while still adhering to Traffic Separation Schemes (TSS). The UKC was set at 20% of the draught or at least 1 meter, which is in line with recommendations set by HELCOM for vessels in the Baltic Sea. A Safety Ellipse, suggested by Fuji, surrounds the vessel with a semi major axis, four times the ships' length. The optimisation is made on one specific ship model with the assumption that the relative fuel consumption as a function of speed is around the same for most vessels.

Traffic analysis

The optimised routes generally show a more concentrated traffic pattern. This is not surprising, since a shorter route is beneficial for any vessel. Finding a shorter route also means that the speed can be reduced, which has a heavy impact on the optimisation. In some areas traffic has a wider lateral spread, often an effect from vessels of a higher draught need more depth. Some optimised routes are placed in new areas that must be further investigated in terms of nautical considerations.

A significant change in the traffic pattern is the removal of the two "doglegs" in the old pattern route. These doglegs emerge from recommended routes on the chart, but it is possible to take a straighter route. Considering the traffic volume, approximately 20,000 nm could be saved on an annual basis when avoiding the doglegs. The average saving for the transit traffic with optimised routes is generally around 12%.

The depth information is vital for optimising a route taking into account the increased hull resistance due to squat, which should be considered in shallow waters like the Baltic Sea and many other European waters.

Although this study is limited to a specific region, we have demonstrated a novel voyage optimisation tool suitable for use in shallow waters that are common in Europe and other parts of the world.

Co-financed by the European Union
Trans-European Transport Network (TEN-T)

Facts about MONALISA

MONALISA (Motorways & Electronic Navigation by Intelligence at Sea) started in early 2010 aimed at improving safety and optimisation of ship routes in line with the EU's Baltic Sea Strategy. MONALISA is co-financed by the EU, Trans-European Transport Network (TEN-T) and the Västra Götaland Region.
The project is coordinated by the Swedish Maritime Administration and partners include SSPA Sweden AB, the Danish Maritime Administration, Finnish Transport Agency, Chalmers University of Technology, SAAB TransponderTech AB and GateHouse A/S. The project ends in December 2013 and is followed by MONALISA 2.0, where SSPA will implement a concept of traffic coordination into the green routes and carry out risk analysis tasks.

Read more at:
www.monalisaproject.eu