MONALISA 2.0 – Sub-activity 1.6

Tools for decision support, route planning and anomaly detection integrated, verified and tested in a STM system

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1. Introduction and summary

In the MONALISA 2.0 it was recognised that the concept of Sea Traffic Management (STM) would depend on tools for decision support, route planning and anomaly detection amongst others. These tools and services are presented in this report and a few of them are also available as web services. The tools and services will depend on different kind of information, especially geographical information, and within the activity Geoportal was developed for the distribution of this data. The reliability of data has also been improved in this activity with regards to weather forecasts, visibility and currents.

The partner involved in this activity were:

- Carmenta
- CIMNE
- Danish Meteorological Institute
- Navicon
- Swedish Meteorological and Hydrological Institute
- SSPA Sweden AB

This report serves as a consolidated executive summary of the partners work within this activity. The full reports that are the foundation of this report can be found at the project portal at URL: https://service.projectplace.com/pp/pp.cgi/0/888405764?op=wget#folder/903695762

2. Geoportal, SeaSWIM, Services & tools

Sea Traffic Management (STM) is about sharing information so that everyone knows where everyone is going. It is about getting an improved situational awareness. To accomplish this Carmenta has during the project worked to promote service oriented solutions and geographical web standards provided by the Open Geospatial Consortium (OGC).
To show the use of a service oriented exchange of geographical information in practice, Carmenta have developed the MONALISA Geoportal. The Geoportal makes geographical data from various stakeholders in the project available as standardized OGC web services.

SeaSWIM is an infrastructure, with influences from the aviation sector and SESAR, for sharing information between sea traffic stakeholders in an efficient way, making the right information available to the right people at the right time. To prove the concept of SeaSWIM Carmenta has developed a SeaSWIM demonstrator, where a web client in a service oriented manner, consumes both web services for maritime analysis developed by Carmenta and web services presenting maritime data from providers within the MONALISA project.
The demonstrators have shown that a Service Oriented Architecture (SOA), according to the SeaSWIM concept, is powerful and well-functioning. Maritime data have been made available and visualised through web services. Furthermore, web services have been combined to display data in merged visualizations. Finally, an added functionality for analysis, has used the data available to create and visualise the results as new services to the users of the SeaSWIM community.

In addition to web services providing basic maps, externally provided web services are utilised and their combined use with Carmenta’s services make up tools in the web client. This section will describe the most important services used, and how they are utilised in the web client.

- Routes are provided by Transas.
- MSP areas are provided by the World Maritime University.
- Weather Data is provided by Jeppesen.
- Sea chart and depth data is provided by the Swedish Maritime Administration.
- Analytical services provided by Carmenta.

The SeaSWIM demonstrator has also proven the strengths of the concept where all parties can be both producers and consumers of the shared data and functionality. This
ability will be a vital support to the MONALISA device “Need to share” as one of the most important factors to make STM go operational.

There are a few issues still to be addressed in getting SeaSWIM afloat. Ship connectivity, data security and a user forum, where all parties can register available services and establish business contacts. All these issues will be addressed in the STM project. It is Carmenta’s strong belief that the SeaSWIM concept will be one of the important enablers of the STM environment. SeaSWIM will ensure interoperability of STM services, facilitating data sharing using a common information environment and structure to all parties.

Furthermore, it is important to base SeaSWIM on international open standards, for geographical data purposes OGC is an excellent forum to enable this

### 3. Route evaluation service

CIMNE has developed a route evaluation service in this work package which evaluates a number of alternative routes taking into account several environmental and efficiency parameters to suggest the best alternative in the decision making process. The service takes the following criteria into account to evaluate each route:

- IMO safety guidelines
- Ship particulars and operating conditions
- Weather forecast
- Environmental protected areas

**Input arguments:**

- Routes – List of routes in RTZ exchange format
- FuelConsumptionWeight- This parameter weights the importance of fuel consumption with respect to time for the evaluation. A value between 0 and 1 is expected.
- VesselLength - Length overall of the vessel. (Not part of Route Exchange)
- VesselPower- Power of the vessel. (Not part of Route Exchange)
- SpecificFuelConsumption – Specific Fuel Consumption of the vessel. (Not part of Route Exchange)
- ContainerShip – True if the vessel is a container ship. False for other kind of vessels.

The service has been deployed as a SOAP web service using standard Internet protocols to enable full interoperability with external systems.
The route with the best evaluation is displayed in blue while the other two alternatives are shown in grey. The result of the evaluation of the route is displayed when the user clicks on the route displayed on the map.

The routes are evaluated individually obtaining a result that takes into account fuel consumption and time of travel. A special result is obtained if any of the IMO safety rules are not fulfilled or if the route crosses a protected area.

4. Improvement of Met-Ocean products

The weather and ocean forecast products provided by DMI to Carmenta include both weather and ocean parameters: winds at 10m height, visibility, waves, surface currents and sea level. The products mainly cover the Baltic and North Sea. These products have been used for route optimization experiments and EMSN tests in MONALISA 2.0 project. Besides from providing forecasts to partners and the test bed, the topics below were studied in more detail to achieve improvements in in future predictions of waves, visibility and currents.
4.1. Ensemble wave forecast for the Baltic-North Sea region

Ensemble prediction on METOC variables provide more potential for maritime safety risk management, through providing an estimate of the uncertainty of the forecast as well as the probability of a high sea event, e.g., the significant wave height higher than 5 meters. DMI has undertaken to set up an operational ensemble wave model prediction system (WAM-EPS). The system has been tested and run pre-operational at DMI for the Baltic-North Sea region.

The features of WAM-EPS are different between calm sea and high sea states. The figure below shows a typical example of the ensemble wind and wave predictions and comparison with observations at station 62152, in a calm sea state situation. The spread is low and the predictions have a high confidence.

![Comparison between model and observation results for the WAM-EPS (upper panel) and HIRLAM-EPS (lower panel).](image)

For the high sea states, the spread of the forecast is much larger than in the calm sea states. Two examples are shown in the figure below for two storms: one in January 2015 and the other in February 2015. For the January storm case (Fig. 3 upper panel), the significant wave height (predicted by the WAM-EPS) has larger spreads in the two wave peaks, showing larger uncertainty of the forecast; this is also true for the storm case in Feb. 2015.
Comparison between model and observation results for the WAM-EPS in 2015 January (upper panel) and February (lower panel).

4.2. Improve surface current prediction in European Seas

Ocean Surface Currents (OSC) in European regional seas (Mediterranean, NE Atlantic Shelf, North Sea and Baltic Sea) are of high interests and importance to end-users for navigation safety and search and rescue.
The purpose of this study is to develop an efficient and robust methodology to derive high resolution and high quality OSCs in pan-European Seas; DMI has implemented DMI Baltic-North Sea operational model HBM (HIROMB-BOOS Model) for pan-European regional Seas with 9 two-way nested areas (Fig. 2). A model simulation experiment has been carried out during 2006-2014.

The figure above displays an inter-comparison of water level simulated and observed at stations in different sea basins: Stockholm (Baltic), Immingham (North Sea), Socoa (Shelf Sea), Venice and Trieste (Med. Sea). The results show that the observation is rather consistent with the model simulations that suggest that the barotropic signals in the sea are well simulated.

4.3. Improve the visibility forecast in the weather prediction model HIRLAM

Visibility is an important variable for land, air and maritime transportation. In addition to public weather forecast usage, the visibility product is widely needed in commercial
applications such as offshore operations. However, there has not been that much of an effort invested to improve the visibility forecasts in the past decade. The idea is to modify the existing parameterisation formula for calculating the visibility by including some important factors such as stratification. An interface will be built providing necessary DMI-HIRLAM-SKA forecast/analysis data as input to the present and modified visibility subroutine. The research mainly concentrated on the autumn period when fog occurs frequently. The verification of visibility covers Denmark and adjacent waters. The verification should be done for present and modified visibility codes.

This research is still on-going and will be finished in the end of the year. Figure 4 shows the first attempt of testing the two different visibility schemes. It is shown that the new scheme gives much larger visibility, both on the land and the sea.

The figure above shows visibility forecast (in km) at 2015101406GMT made by HIRLAM model with old (left) and new (right) visibility parameterization schemes.

5. Route Anomaly Detector

A vessel that has dubious voyage patterns is hard to be detected manually by simply looking at a vessel travelling, as it is something happening in the long run. This is where this Route Anomaly Detector tool will help. The tool should detect when ships deviate from routes, as this may indicate:

- Dangerous navigation,
- Conduct ship to ship transfer of cargo,
• Potential illegal activity.

To find the normal pattern, AIS Messages received in the area of interest are collected, for vessels with a draught superior to 7 meters. This limitation has been chosen to target in this study only cargo vessels and container ships, since they are vessels that need to follow regular routes and present a clear traffic pattern, unlike fishing vessels. This data is then used by the Route Anomaly Detector to detect vessels that show dubious voyage patterns.

Figure 2 The figure above shows corridors where the course over ground of the vessel is monitored. On the right, the same corridors superimposed with the s52 layer.
Figure 3 The black track is a vessel that started going north, following the tracks in red. However it turned in the north-east direction, in the corridor where the blue tracks go exclusively in the south-west direction. This incident was detected by the Route Anomaly Detector.

The service triggers alerts when a vessel is in the wrong corridor. The operator can also click on a vessel and get the information on how many alerts they have triggered and how much time they have spent in the wrong corridor, thus providing them with a risk factor for the vessel. The tool is used in real life, and its use has been proven. The model of the routes needs to be improved to do justice to the complex patterns of the vessels and reduce false alarms.

A web application is also developed to share the information with the partners. The possibilities via the web application are to:

- Inquire for the risk factor for a vessel,
- Send a route a vessel should be evaluated on.

### 6. Route optimiser & conflict solver

SSPA has developed two services in this work package, one is a route optimiser that energy optimises voyage plans and the other is a conflict solver to de-conflict voyage plans.
First, a geometric method was developed to classify close situations between vessels, mainly intended for use on routes in the planning stage of a voyage. Two vessels that fulfil the definition are called “conflict candidates”.

Secondly, the conflict solver separates vessels’ planned voyages until their safety ellipses have no overlap, not in time nor in space, which in turn can reduce the number of collisions. When solving, the waypoints can be moved both spatially and in time, although the speed on each leg cannot exceed nor go below the vessel’s reported service speeds (part of the Route Exchange specification). The solver will also make sure that the Under Keel Clearance (UKC) requirement is fulfilled.

The analysis is based on one month of AIS traffic in Kattegat, where the original tracks are deduced into planned voyages and then separated.

The picture to the left shows the number of conflicts while the picture to the right shows the reduced number of conflicts after optimisation and conflict solving.
With the current traffic pattern the reduction of the number of conflicts is 99.4% and for optimised traffic the reduction is 97.4%. The fuel savings results from the first MONALISA still holds, in this report calculated to 10.9%.

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<th>Planned Voyage eqv., no Conflict Solver</th>
<th>Planned Voyage eqv., with Conflict Solver</th>
<th>Optimised traffic, no Conflict Solver</th>
<th>Optimised traffic, with Conflict Solver</th>
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<tr>
<td>Fuel Consumption [Metric Tons]</td>
<td>25243</td>
<td>25243</td>
<td>22505</td>
<td>22506</td>
</tr>
<tr>
<td>Nr. Conflicts</td>
<td>337</td>
<td>2</td>
<td>1708</td>
<td>45</td>
</tr>
<tr>
<td>Conflict Reduction</td>
<td>99.4 %</td>
<td>97.4 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Consumption Reduction</td>
<td>10.9 %</td>
<td></td>
<td></td>
<td>(Approx. the same as in the first MONALISA)</td>
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The results show that it is possible to significantly reduce the number of conflicts in the planning stage of a voyage, with limited effect on the fuel consumption. It is shown firstly for the case with planned voyages deduced from AIS and secondly for optimised voyages, for each of them individually.

It is also shown that it is possible to do fuel optimization and still solve almost all of the conflicts, such that there is no trade-off between number of conflicts and fuel efficiency. SSPA has developed a web service interface in order to expose the conflict check/solve interface on the Internet.
39 partners from 10 countries
taking maritime transport into the digital age

By designing and demonstrating innovative use of ICT solutions
MONALISA 2.0 will provide the route to improved

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