D3.3 Optimal Track

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Partners involved

No.	Organisation Name	Name	Email
1	MARIN	Arno Bons	a.bons@marin.nl
2	Via Donau	Juha Schweighofer	Juha.Schweighofer@via-donau.org
3	Autena Marine	Desiré Savelkoul	d.savelkoul@autena.nl
4	VNF	Pierre-Jean	pierre-jean.pompee@vnf.fr
5	DST	Cornel Thill	thill@dst-org.de
6	CFT	Steve Labeylie	steve.labeylie@cft.fr
7	TKV	Bé Boneschansker	be.boneschansker@thyssenkrupp.com
8	Helogistics	Viatcheslav.Vdovitchenko	Viatcheslav.Vdovitchenko@helogistics.com
9	Plimsoll	Szalma Bela	szbela@plimsoll.hu

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1 Executive Summary

1.1 Problem Definition

Restrictions in water depth (and width) are of eminent importance for the energy consumption of inland ships, because engines tend to keep the selected number of revolutions during operation. When the water conditions get restricted, the resistance of the vessel is increasing highly non-linearly and the propellers have problems to get enough water from ahead. Due to both effects the propellers have to work harder and this costs more energy and subsequently fuel. One of the objectives of the EC Planner is to determine the optimal track by taking into account the restrictions on the river.

1.2 Technical approach

Based on the actual electronic water depth chart, which is the result of D3.2 Integration of communication, the optimal track will be determined by the EC Planner. Since restrictions in water depth and width have a negative effect on the fuel consumption, the optimal track follows the optimum of deepest part versus track lengths of this part of a river for a given route.

In addition to the original MoveIt proposal the virtual ship module is added to the EC Planner system to determine the optimal RPM during the voyage, in order to follow the track with a minimum resistance.

1.3 Results and Achievements

The developed EC Planner is able to:

- Generate an actual electronic chart, in terms of actual local water depth
- Determine the optimal track based on the actual electronic chart
- Generate accurate ETA's by means of a voyage plan
- Follow the track of minimized propulsive power demand
- Advice skippers on optimal RPM during the voyage

1.4 Contribution to MoVeIT! objectives

The objective of this work package is to reduce fuel consumption by energy efficient ship operation, by developing the EC Planner. This will be done by implementing the following measures in the EC Planner; installing the EC Planner on board of the 4 selected ships of shipping companies involved, developing a system to share water depth information with other ships, determination of the optimal track on the river and development of an optimal autopilot following the track at the least fuel consumption.

Based on the in situ shared actual local water depth information the EC Planner determines the optimal track. Furthermore, by knowing the actual water depth, the skipper is able to determine the maximum allowable loading draft for his voyage. The aim of energy efficient ship operation is to decrease the fuel consumption taking into account the effects of the restrictions of the fairway. The virtual ship of the EC Planner prevents that more energy is used when restrictions occur. The skipper is advised to decrease the number of revolutions to the best value.

2 Optimal track

One of the goals of the EC Planner is to determine and decide on the best track to be followed on basis of own ship and bottom configuration. Based on the actual electronic water depth chart, which is the result of D3.2 Integration of communication, the optimal track will be determined.

First the skipper has to provide a ETD, ETA and a route in the user interface of the voyage planner. A route is just a sequence of waypoints to indicate the point of departure and arrival and which fairways have to be taken. Based on these provided input, the EC Planner will download a table of water depths en GPS positions from the Autena server, see also D3.2 Integration of communication.

Based on a given route, the EC Planner determines the optimal track by looking for the deepest parts on the river, taken into account the turning circle of the ship. The red line in Figure 1 shows the optimal track on the ECDIS. A prototype of a user interface of the EC Planner is given in Figure 2.

Furthermore, the skipper is advised on optimal RPM (number of revolutions per minute) during the trip as determined by the virtual ship of the EC Planner. To achieve this, the virtual ship requires the optimal track, divided in a number of legs with corresponding gradient, current speed and water depth as can be retrieved from the Deltares prediction calculations, see also D3.2 Integration of communication.

Furthermore the ETA, the initial loading condition, main ship parameters and engine characteristics are required. The first check of the virtual ship is whether the ship with the intended load is still able to execute the voyage. When an ETA becomes critical the ship may use its maximum power to meet the ETA but that should remain an exception. To meet an ETA there is a solution that provides a minimum by choosing variable speeds over the legs in case the maximum power is not used. This might mean that on a given leg of the route maximum power needs to be used to compensate for the slower speed on the shallower parts. The output, including RPM advice, of the virtual ship calculation will be provided in a small table for each leg as shown in the figure below.

Note, the results of the measurements are required to calibrate and further improve the current virtual ship. Also the definition of “optimal track” is still under investigation as the local water depth is not constant and changing in time. In some cases it makes sense to “wait” for a increasing local water depth, e.g. as a result of whether and surface water discharge, and to make up the waiting time by exploiting this water “wave”. These considerations under investigation by MoVe IT! Partners such as DST are not yet implemented in the EC planner V1.0, but could be part of a next release.

Please note, the description of the design overview of the EC Planner including the file formats of data that have to be exchanged between the different modules of the EC Planner, the technical description of the interfaces and several use cases is completed in “Economy Planner Interface Overview” [1] and “Economy Planner use Case Overview” [2].

Figure 1: Optimal track presented on ECDIS, based on actual water depths

Figure 2: Prototype User Interface EC Planner

3 Bibliography and References

1. Molenmaker Kor, MARIN, Economy Planner Interface Overview, September 2013
2. Molenmaker Kor, MARIN, Economy Planner Use Case Overview, September 2013

4 Indexes

4.1 Index of Figures

4.2 List of Abbreviations

EC Planner	EconomyPlanner
ECDIS	Electronic chart display and information system
ETA	Expected time of arrival
ETD	Expected time of departure
GPS	Global positions system
RPM	Revolutions per minute