Final Report

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1. Publishable summary

The MoVe IT! project is executed within the European 7th framework package and is also funded through this research program. It started in 2011 and finished in 2014. The project focussed on exploring and determining viable retrofit solutions for existing inland ships in order to increase environmental and economic performance. The average age of inland ships is above 40 years and that implies that modernisation of the fleet via new building will take decades. Given the need to improve the environmental and economic performance, the long lifetime stresses the importance of improving existing inland ships. This is where retrofit solutions fit in.

The most promising retrofit options selected by ship owners and experts were:

1. Improving propulsion by using a pre-swirl stator, a number of blades before the propeller, to improve the inflow to the propeller.
2. Optimisations of the stern form (tunnels) in order to improve the flow to the propeller.
3. Reduction of drag of gondola's, of rudders by optimizing the shape Removing flanking rudders and removing of struts form the propeller nozzles
4. Replacement of main engines
5. Improving power management, application of waste heat recovery.
6. Applying SCR (Selective Catalytic Reduction) + particle filters compared to applying NOx and PM reduction.
7. Lengthening a ship.
8. Applying trapezes (bodies) between the bow of the ship and the barge pushed by this ship in order to smoothen the flow between barge and ship, resulting in less resistance.

This overview of selected retrofit options shows that the ship owners expressed very little interest in power-related retrofits. The reason behind this is that emission abatement techniques such as filters and catalysts can only lead to very limited fuel savings, sometimes leading to an increase in fuel consumption, while there are little to no other economic benefits, thus making these techniques business wise unattractive. Other solutions like LNG, CNG, Fuel cell, diesel electric or all electric propulsion all require major modifications to the engine room and large investments, thereby making them unattractive as well.

Also it appeared from the choices of the ship owners that apparently there is no universal desirable retrofit solution for inland ships. This conclusion is supported by the MoVe IT! experts: in order to improve the performance of an existing inland ship, it is necessary to make an analysis of that specific ship and its operation. Since the design and operational profile of each ship is different, so are their strong and weak points. There is no single universal solution which is effective for all ships. This supported the approach of developing guidelines to apply by ship owners when considering an improvement of their vessel.

Guidelines have been developed and published in a format that is accessible for ship operators and ship owners, covering different areas;

1. General guidelines
2. Hydrodynamic Improvement
3. Efficient Ship operation
4. Powering and Engines
5. Ship Structures & Weight
6. New Scale and Service

MoVe IT! learned that modernisation of inland ships needs a customised approach, taking the economic effects into account and stresses the need for further development of relative low-cost mathematical tools for the different types of analysis needed in assessing the options.

2. Scope and Objectives of MoVe IT!

Scope

In order to cope with the fierce competition and the predicted cost increase, inland waterway transport companies have to continuously develop and improve their efficiency and their environmental performance. Given the long lifespan of ships, this is not just a matter of continuous improvement of the design of new vessels, but also has to deal with improving and modernising existing ships. A significant proportion of the current fleet is over-aged and thereby does not meet the economical, environmental and safety standards of tomorrow.

To enable a short- or medium-term implementation of new technical developments MoVe IT! focussed on retrofitting of the existing fleet, also given the knowledge that in the past most research activities have been focused on the improvement of new-buildings, and it is difficult to apply these results to the modernisation of the existing fleet.

Objectives

The MoVe IT! project aimed to accelerate the implementation of new developments into the existing inland fleet in order to sustainable strengthen economic and environmental performance and competitiveness of the inland navigation companies and thereby also improve environmental performance of the inland waterways transport.

The project focussed on a diagnosis of the existing fleet at the start of the project. On basis of the diagnosis reports the modernisation approaches were analysed and elaborated. These improvements comprised both the construction of the ship as well as the ship operation.
Among others, available research results referring to the new-building of vessels and other modes of transport has been analysed to determine to what extent they could be transferred to a retrofitting of the existing fleet in an economically efficient and ecologically sustainable way.

The project had to provide a relative simple, guided support for inland navigation companies in order to enable them to assess the economic advantage of modernisation measures by comparing and assessing necessary investments. This guide provides an rough insight in costs regarding the retrofitting measures considered and on the other a description of the impacts on ship operation and thereby the basis for the evaluation of benefits.

Approach

The figure below (next page) provides an overview of the approach and illustrates the way the different work packages interacted.

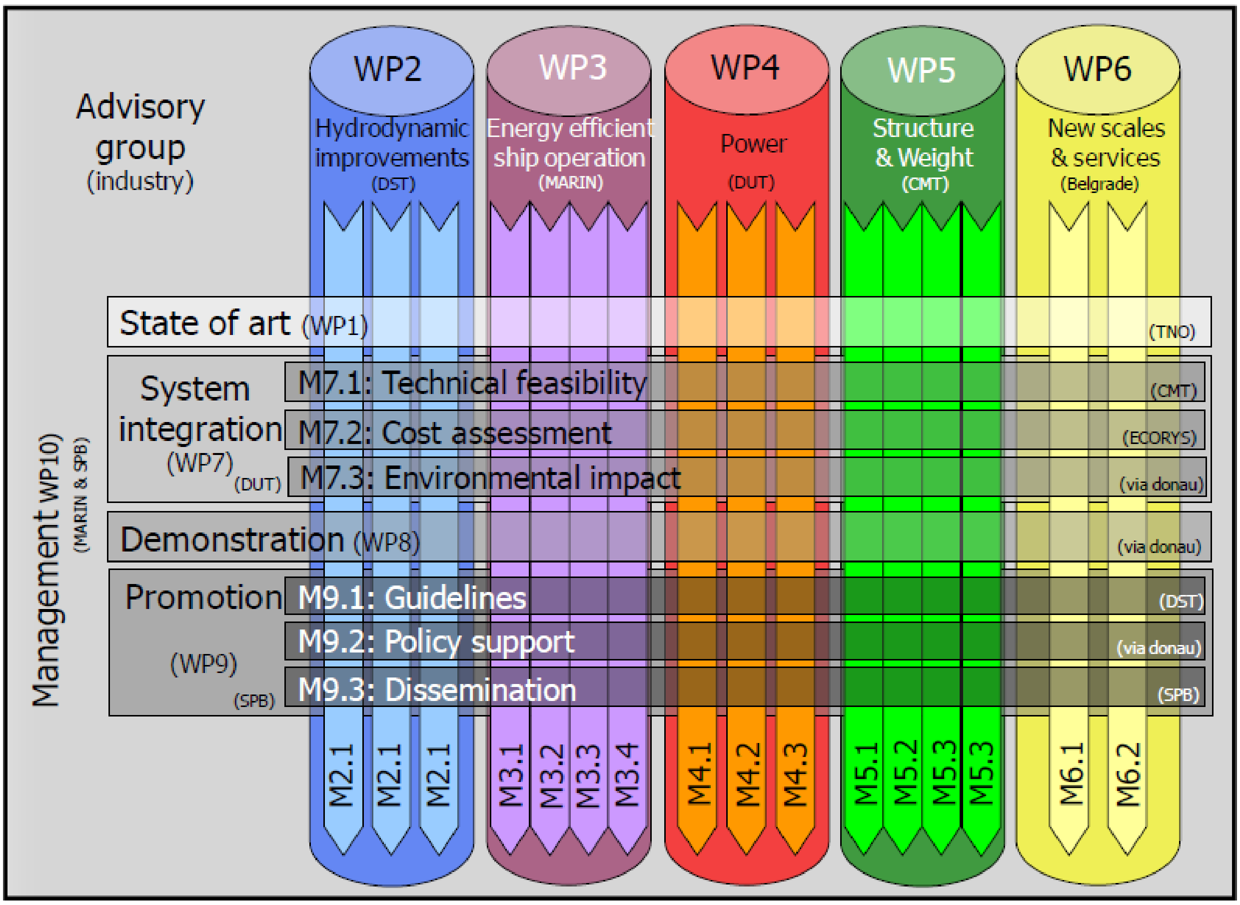

Figure 1: MoVe IT! Structure

The project started with the analysis of the „Status quo“ („State of the art & measurements“) (Work Package 1 - WP1) covering the state of the art in each of the 5 proposed areas of modernisation measures for retrofitting. Within this work package the results of former research on techniques for new ships and other modes of transport were addressed with regard to their applicability in retrofitting in inland ships. In addition, measurements were realized on the current fleet to define the current state of the fleets performance and to gather indispensible information for improvement of existing ships and systems.

The following 5 areas for retrofitting (WP2 – WP6) formed the main research focus of the project:

- WP2: Hydrodynamic improvements
- WP3: Energy efficient ship operation
- WP4: Power WP5: Structure & weight
- WP5: Structure 7 Weight
- WP6: New scales & services

The work packages 2, 3 and 4 started with a focus on the environmental performance by reducing energy demand and emissions. In addition the economical performance was addressed in terms of the reduced fuel consumption. WP5 addressed questions of dangerous goods transport, related safety aspects and the adaptation to expected future ADN requirements. WP6 analysed possibilities of dimension enlargement and new service options e.g. in terms of new operation areas or new market segments.

WP7 focussed on the vessel as a whole, integrating the results of the different research areas and addressing the interactions and dependencies, as well as on economical feasibility and impact on the environment of the overall solution.
The second aim of this work package was to gain information on the relative importance and „usefulness" of the various measures (or combinations of measures), thereby considering tools and suitable benchmarks for economic, environmental and safety performance of the various measures and vessels types.

The promising modernization approaches for different types of vessels are visualized via demonstrators developed in WP8.
Finally the appropriate strategies and steps, which support the implementation of these measures have been dealt with in WP9 "Implementation Support and dissemination" which focused on:

1. Guidelines for modernisation, addressing vessel owners and consulting offices.
2. Dissemination.

3. Scientific and Technical Results

In this chapter the results of the MoVe IT! project are summarized per work package, for the work packages 1 up to and including 8 . WP9 “Dissemination” is dealt with in chapter 4.

3.1. WP1: State of the art and measurements

This work package consisted of two parts:

1. Identifying and assessing existing concepts and solutions. An inventory has been made on retrofitting opportunities/concepts, categorized by four topics:
   a. Hydrodynamics
   b. Ship structure
   c. Mechanical installation
   d. Operations
2. Measuring performance of existing ships.

Existing solutions/concepts
The conceptual retrofitting ideas were all focused on establishing more cost-effective and sustainable ways of shipping. The most promising retrofitting opportunities per category are:

a. Adjustable hydrodynamic appendages are worth investigating, e.g. the adjustable bulbous bow and tunnel.
b. The combination of different materials, resulting in hybrid structures, are very interesting from a weight and strength point of view. In addition, the use of hybrid sandwich panels in the side structure, may provide increased crashworthiness.
c. An obvious retrofitting option is changing to LNG fuel. Most probably this requires an LNG-electric installation.
d. The use of traffic control and online voyage planning through adjusted ship operation: very interesting and promising in terms of noticeable fuel reductions.

Performance measurements
In discussion with the participating shipping companies 5 vessels have been selected, to determine the performance by means of full scale measurements. Three push barge convoys were selected and two self propelled barges. During the measurements i.e. speed, RPM, water depth and fuel consumption were measured. A benchmark of the ships has been carried out on the basis of the results of the measurements and the experience available in data. It is very difficult to make a fair comparison, because the speed trials have been performed in different sailing areas. However when comparing the self propelled barges with the benchmark it can be concluded that both vessels are performing below average. When comparing the push barge convoys, one vessel was performing very well, the two other vessels were performing below average. The vessels performing below average were further investigated within MoVe IT! by means of CFD calculations.

3.2. WP2: Hydrodynamic improvements

Work package 2 dealt with retrofit options from a hydrodynamic point of view. Suitable options were analyzed (via literature and additional numerical computations). And model tests were done for the validations of experimental data.

This WP started with the results of the measurements aboard of the five vessels in WP1 and consisted of the following tasks:

- Analyses of the performance of the ships measured in WP1.
- Selection of retrofit options (improvements) and numerical calculation of the effects of the hydrodynamic improvements.
- Further optimization of retrofit techniques focused on hydrodynamic aspects in order to reduce resistance, optimize propulsion while maintaining (or improving) maneuverability.
- Research on the applicability of the EEDI concept of seagoing ships for inland ships in This concerns the ranking of the performance of a ship (and the effect of improvements) with respect to energy usage. For seagoing ships the EEDI – Energy Efficiency Index – is a tool to benchmark the energy performance. It was introduced by the IMO.

The results of this WP were used in realizing demonstrators (WP8) and developing the guidelines for retrofitting inlands hips (WP9).

Carpe Diem
For the self propelled barge Carpe Diem two retrofit measures were investigated. First there was investigated with potential flow calculation if the wave making resistance could be reduced by modifying the bow. Based on these calculations the following could be concluded:

- The wave generated by the ship is good compared to that of similar vessels, therefore no significant gain is expected after modifying the bow.

Secondly the viscous flow around the gondolas was investigated. Based on this investigation the following recommendations were done:

- The gondolas should be oriented slightly inward in order to be aligned with the fluid and avoid the flow separation.
- The size of the gondolas are considered big. A reduction of it length is recommended.
- An increase of the distance from the end of the gondola to the propeller plane is recommended in order to improve the wake field.
- Smooth the end of gondola.

Based on this study, MARIN has proposed a hull modification of the ship. This new hull form only affected the aftbody of the gondolas.

Herso
The HERSO is a self propelled barge, most of the time sailing with the same barge in front, the Leonie SL. (sailing as a coupled unit). Between the barge and the vessel a large gap is present. In this study the effect of a trapeze was investigated: a trapezium shaped body in order to smoothen the transition between barge and ship.

Therefore numerical calculations with and without gap have been performed. With respect to these trapezium shaped bodies, the following conclusions apply:

- When not applying a smoothened transition the boundary layer along the pusher is rather thick due to the flow reversal behind the barge. When applying a smoothened transition the boundary layer becomes thinner. The thinner boundary layer is beneficial from resistance point of view; an indication for the resistance with and without smooth transition shows a resistance decrease of 20%.
- The transition as calculated might be impractical to build. A less drastic approach could be followed leading to less resistance decrease than indicated before. However, most of the resistance decrease is related to the removal of the flow reversal area.

Inflexible

For the pushboat Inflexible there was investigated if the aftbody could be improved by retrofitting. Therefore viscous flow calculation has been performed for the original hull lines in order to determine the options for improvement. The analysis led to the a more optimized hull design by smoothening the bow thrusters gondola as well as the shaft bossing. This results into an improved hull shape. For this new shape viscous flow calculations have been performed to determine the gain:

- The improved hull shape has an estimated 8 % reduction in resistance compared to the original shape. For the push-convoy as a whole this corresponds with a resistance reduction of 1 to 1.5 %

The following recommendations were formulated:

- **Nozzle**: The duct of the nozzle seems quite thick. Improvements might be possible applying a more slender nozzle.
- **Knuckle lines**: Sharp edges in the hull can be made more rounded.
- **Propeller**: Improvements can be made by using an optimized propeller. This could lead to a power reduction in the order of magnitude of 2 %.
- **Rudder**: The rudders seem quite large and bulky. The more efficient design may increase manoeuverability and decrease resistance.

Dunaføldvar

The pushboat Dunaføldvar was equipped with flanking rudders. The retrofit measurement investigated for the Dunaføldvar focused on the effect of removal of the flanking rudders via numerical calculations.

- The flanking rudders cause a decrease of forward thrust of 3%. Since these rudders are well aligned with the flow in this case, this should be seen as a minimum.
- The end plates of the flanking rudders are not aligned with the flow and therefore generate vortices that are ingested by the thrusters. These probably cause extra cavitation and vibrations of the propeller.
- The pressure resistance on the hull increases with a factor of four when the propeller action is taken into account. This is due to the concave shape of the aft part of the hull. The jet that comes out of the nozzles hit this part of the hull and increase its resistance, decreasing the effectiveness of the thrusters.
- There is some propeller induced flow separation in between the nozzles. Due to the high loading of the nozzles streamlines in between the nozzles close to the hull deflect to be ingested by the nozzle due to the high loading.

- The shallow water causes more water to be drawn to the thrusters from the side which means it flows around the relatively sharp edge of the aft part of the hull. This causes 3D flow separation and therefore strong vortices that are generated.
- The results of the resistance computations are sensitive to the size and shape of the separation regions. This is probably due to the combination of the instable nature of these regions and the steady state computations. This has an effect on the accuracy of the calculated resistance.

In addition some propeller calculations have been performed to investigate if an optimized propeller could increase the propulsive efficiency. Based on these calculations the following conclusion was drawn:

- The propeller has a blunt leading edge causing sharp low pressure peak near the leading edge during the full rotation of the blade. This causes cavitation during the full rotation of the blade. Reshaping this leading edge reduces cavitation significantly. Blade area ratio can therefore be reduced and around 1% efficiency can be gained.

Energy Efficiency of Inland Waterway Self Propelled Ships

The main objective of this analysis is to establish a benchmarking tool for Inland Waterway Self-Propelled Cargo Ships (IWW SP) with respect to energy efficiency and carbon emissions. In this development, concept of the EEDI index for seagoing ships have been used were possible. The developed index is applied (shown) for two IWW SP ships – MV Herso-I and MV Carpe Diem. These ships were also investigated within WP 2.

Indicators for the sea-going ships already exists, such as Energy Efficiency Design Index (EEDI) and Energy Efficiency Operational Indicator (EEOI), both introduced by IMO. The EEDI for new ships is an important technical measure and it aims at promoting the use of more energy efficient, hence less polluting engines and other equipment. The EEDI requires a minimum energy efficiency level per capacity mile for different ship types. On the other hand, the EEOI enables operators to measure the fuel efficiency of a ship in operation and to gauge the effect of any changes in operation. Therefore, it was reasonable to apply the same methodology on IWW SP ships.

Nevertheless, according to results of the analysis which is based on 107 IWW SP cargo ships (90 Danube and 17 Rhine ships), the EEDI as defined by IMO couldn't be used for reliable comparison of energy efficiency, due to various reasons which are mostly related to specific navigational conditions. Therefore, a modification of existing approach is proposed. Namely, while IMO EEDI is based on predefined engine power (75% of installed engine power) and on expected/achieved ship speed (reference speed), *the modified EEDI - defined here as EEDI* -* is adjusted to IWW ships and is based on the predefined service speed of a ship and corresponding engine power (reference power) required for achieving that speed. Accordingly, reference curves and reference surfaces for deep and shallow water (h=5 m) are developed.

As an example of application of proposed approach for energy efficiency evaluation, the EEDI* values of two IWW SP ships already participating in the MoVe IT! project haven been calculated.. The single-propelled shallow draught Danube ship MV Herso-I, and the 2-propeller Rhine ship MV Carpe Diem. Both ships were full-scaled tested (speed/power trials) by MARIN within Move IT! WP1. In addition, MV Herso-I was also model tested in DST. Measured values were recalculated to standard water depths (deep and shallow water of 5 m) enabling evaluated attained EEDI* to be compared with the corresponding reference curves (which were extracted from the developed EEDI* reference surfaces).

It should be underlined, however, that proposed procedure for EEDI* evaluation has too many uncertainness in:

a) trial procedures,
b) extrapolation from model- to full-scale (service condition), and
c) correction methods.

All of these significantly influence evaluations regarding the energy efficiency of IWW SP ship, hence influence benchmarking too.
Consequently, further research, directed towards determination of "see margins" (river margin) for IWW SP ships is strongly recommended.

Below the results of the calculations for the Carpe Diem are presented.

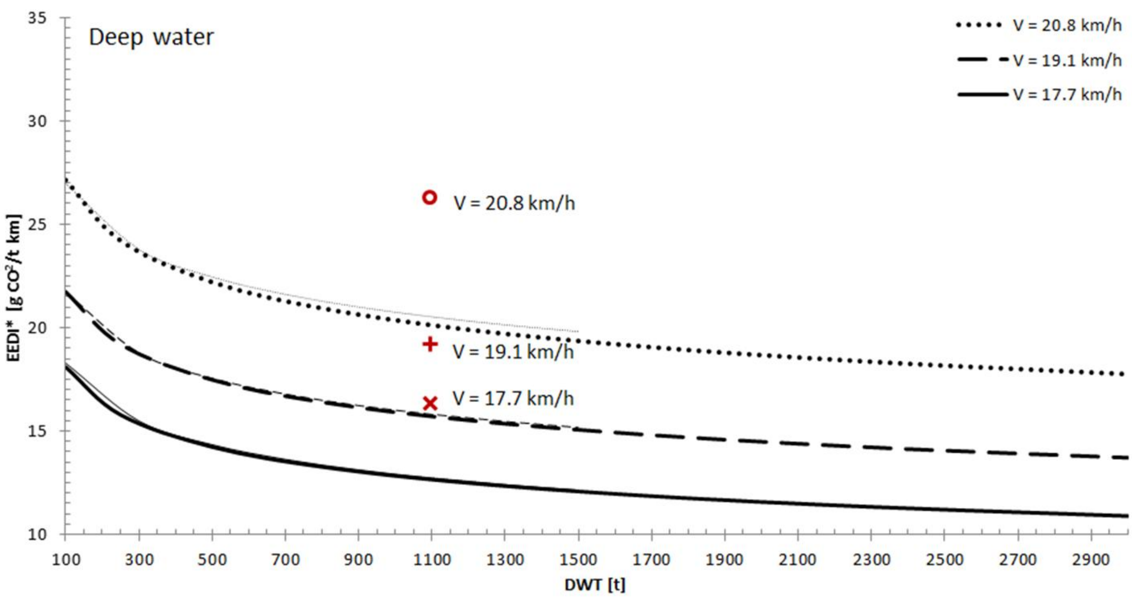

Figure 2: Measured EEDI* (dots) compared to **corresponding baselines MS Herso**

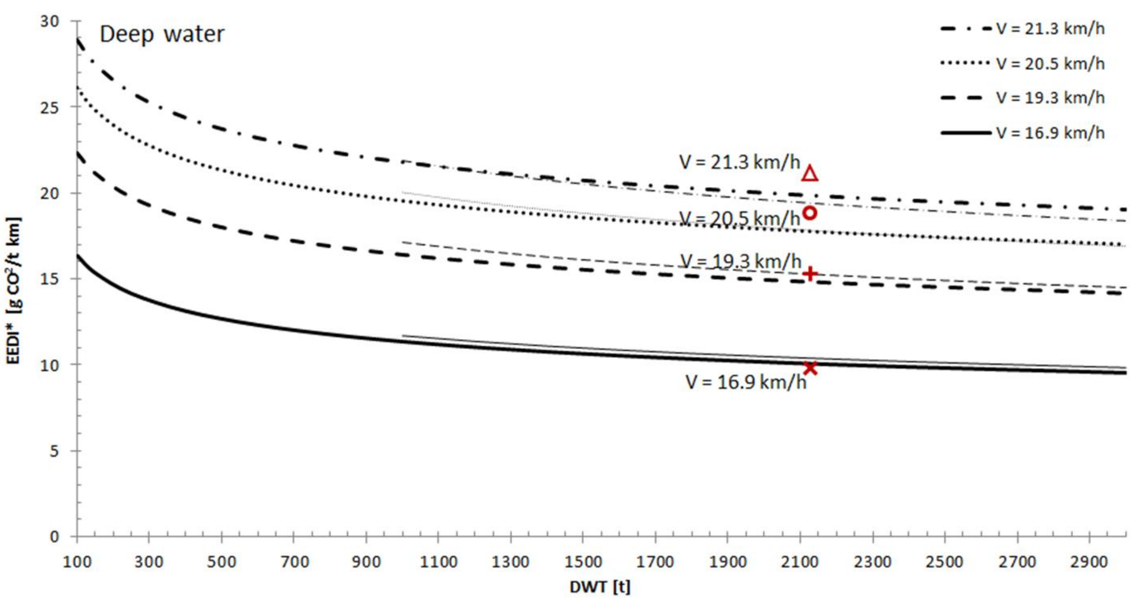

Figure 3: Measured EEDI* (dot) compared to corresponding baselines MS Carpe Diem

3.3. WP3: Energy efficient ship operation

Restrictions in water depth and width are important factors in the energy consumption of inland vessels. In confined waters the resistance of the hull increases and the propeller hull interaction becomes less favourable, resulting in a reduced propeller efficiency. These effects lead to an increased fuel consumption.

The original goal this work package was to install an autopilot that was able to follow a determined optimal track with a minimum loss of steering energy. In designing and realizing this, it became clear that scaling up the principle of collaborative data and further research of determining an optimal track was needed before further developments of other EconomyPlanner functionalities could be realized. This resulted in a revised content and planning of this work package, focussing on generating a real time water depth chart based on collaborative data measurements of 40 participating vessels.

The economy planner concept.
The concept of the economy planner integrates both static and dynamic information of both current and upcoming situation in order to provide the best possible voyage information and planning in terms of economy, environment, efficiency and logistics. The system architecture of the economy planner is presented below.

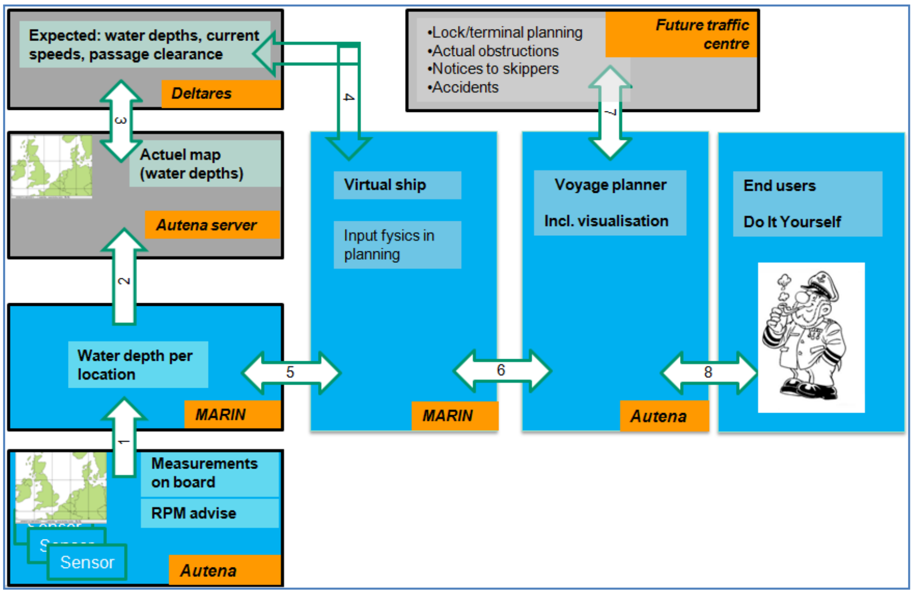

Figure 4 System architecture of EC Planner

A fully developed EC Planner should be able to:

a. Generate an actual electronic chart, in terms of water depth
b. Determine the optimal track based on the actual electronic chart
c. Determine the maximum allowable loading condition
d. Generate accurate ETA's by means of a voyage plan
e. Follow the track with a minimum of resistance
f. Advice skippers on optimal RPM during the voyage

In realizing the first step of the functionality the generation of a electronic local water depth chart, MoVe IT! Cooperated with the Dutch Covadem project. Equipment was installed aboard of 40 vessels. These vessels, navigating the European inland waterways, continuously sharing water depth information. The echo-sounder, loading gauges and GPS already present onboard an inland vessel are linked to one another via a compact device of the EconomyPlanner. Each second this device gathers data from these sensors and every hour this collected data is forwarded to an on shore server, Figure 5: A compact device enables inland vessels to share sensor data like GPS, loading gauge and echo soundings with the server.

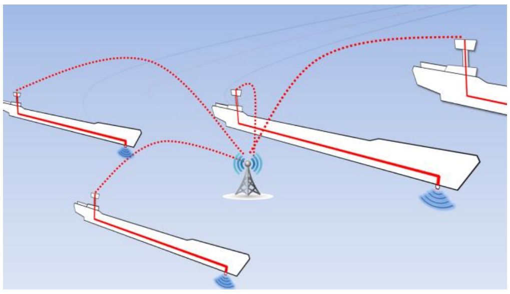

Figure 5: A compact device enables inland vessels to share sensor data like GPS, loading gauge and echo soundings with the server.

The gathered data is processed in order to determine the water depth. In order to determine in the local water depth, the measured under keel clearance is corrected for initial draught and squat. (Squat is the reduction of under keel clearance resulting from bodily sinkage and change of trim, which occurs when a vessel moves through the water, especially in confined water.)

The navigable waterway is divided in a grid of 25 x 25 [m] squares. For each grid cell a water depth is determined. Every second, vessels equipped with the EconomyPlanner provide measurement results. This measurements are coupled to every grid cell they pass during a preset time interval (e.g. 3 hours). Next, the data processing unit of the EconomyPlanner will correct this data for initial draught and squat effect in order to determine water depths in centimetres. In case more than one water depth result is available for a grid cell, the mean value will be used. The following use cases are possible for each grid cell:

- No water depth results are available during the preset time interval. So, the water depth cannot be determined for this cell. In the follow up projects water depth values for these cells will be determined by using history data and interpolation between cells containing a water depth value.
- In between 1 to 4 water depth results are available during the preset time interval. A mean water depth value with a low reliability can be determined for this cell. The cell will get an orange boundary. An example is given in Figure 6.
- More than 5 water depth results are available during the preset time interval. A (mean) water depth value with a high reliability can be determined for this cell. The cell is shown with a green boundary.

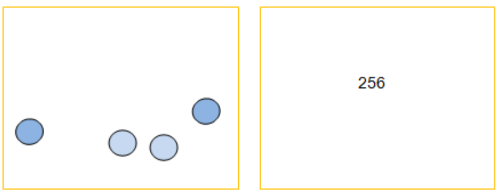

Figure 6: Grid cell with calculated water depth in centimetres based on 4 measurements

Incorrect measurement data and calculated water depth data will be filtered by the data processing unit of the EconomyPlanner. Finally a real time water depth chart can be generated and presented on a Google Earth map, as shown in Figure 7. The cell colours vary from green (deep water) to red (shallow water). Please note, the current water depth chart presented in Google Earth with the chosen cell colours are just a choice made by the participants of WP3 to show that it is possible to create a reliable real time local water depth chart based on cooperative depth measurements. In the future a further discussion with ship owners is required about the representation of real time water depth data, which is convenient for them.

For research purposes, besides the water depth value, the number of measurement results and the number of vessels who provided these data are shown for each grid cell, see Figure 8.

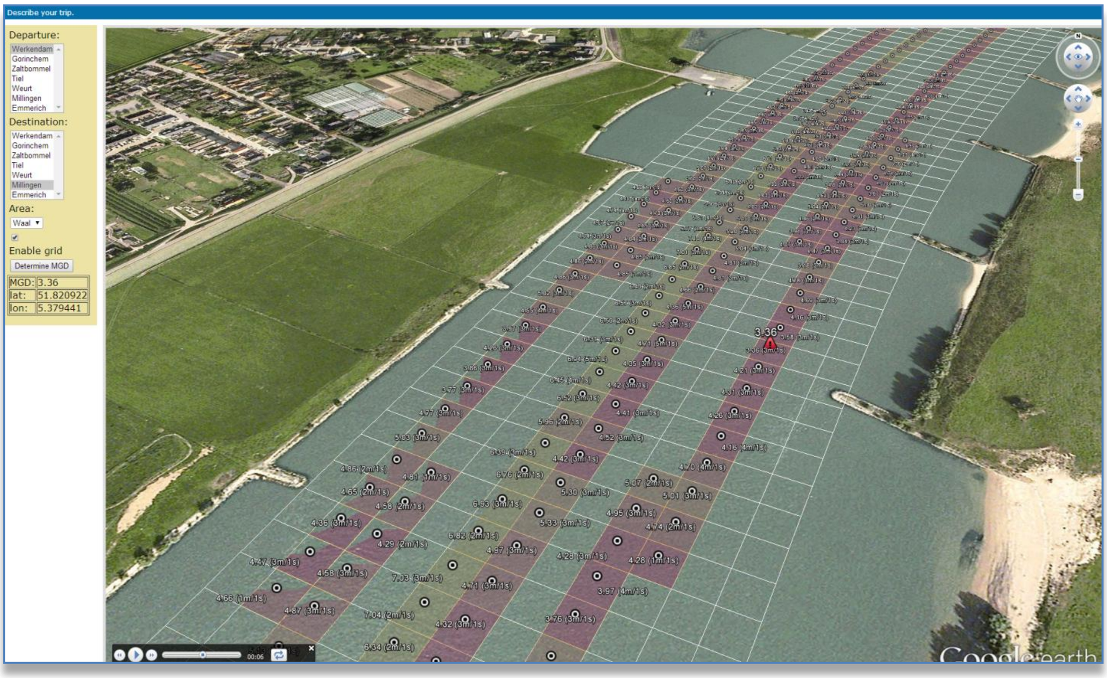

Figure 7: Real time water depth chart presented on Google Earth

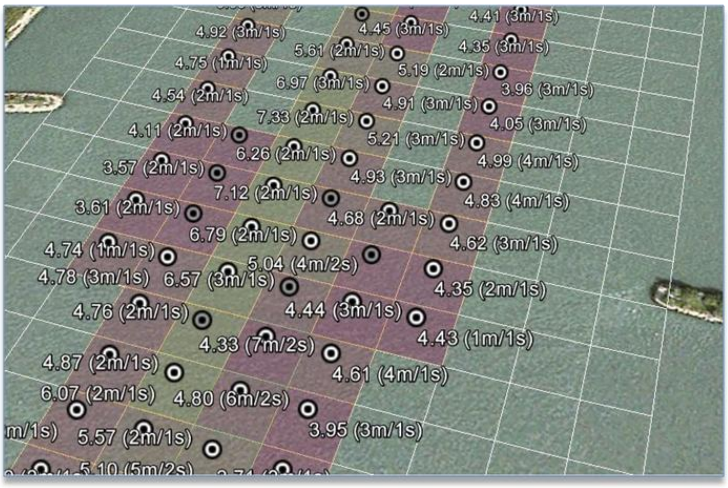

Figure 8: Water depths based on cooperative depth measurements

First quick checks regarding the accuracy of the results are promising. Several water depths calculated by the EconomyPlanner have been compared with reference measurements. With respect to this accuracy it is important to mention that it is the main goal to provide real time water depth information along the entire route and entire voyage of vessels using the European inland waterways, with at least the same accuracy as the currently available water depth information. Nowadays, water depth information is not always real time and not available for every part of the European waterways.

The validation of the determination of water depth of cooperative depth measurements is continued by the partners in the Dutch Covadem project.

Apart from the development of the Economy planner in Western European fairways, the situation at the Danube has been explored. Here two situations were distinguished:

a. Longitudinal (1D) route planning can work with profiles of discharge, water level and bed cross sections, with the purpose of planning the trip from departure to the next stop-over or to the final destination
b. Lateral (2D) route planning calculates short-term ship dynamics using the horizontal fields of flow velocity and water depth, and thus allows the optimisation of safety, fuel or speed.

This study led to the following conclusion concerning the usage of an EconomyPlanner on the Danube waterway;

- From technical perspective there is a potential at least on 1D and 2D level to provide correlations between water discharges, water levels and current speeds of water that are necessary inputs for the EconomyPlanner.
- For these calculations, one potential source of the necessary water levels is the data from ENC (Electronic Navigational Chart), but an important problem with the current supply of maps is the significant difference in quality of the maps (reliability, maintenance, update frequencies) and the absence of standards with respects to this.
- An other possibility to get proper water depth data is the direct measurement by vessels navigating on the river. The Covadem project demonstrates that it is possible to create a reliable depth chart using a standard depth gauge on board and a limited number of vessels navigating in a certain area. However, as it was mentioned earlier, on some stretches of the Danube the river bed changes so frequently that it may more easily happen that the number of depth measurements of the fleet is not sufficient to provide enough data. Data transmission via the web also has its limitations and it should also be mentioned that a lot of Danube vessels has old, analogue depth gauges that must be first replaced to be able to transfer the proper dataset. On the positive side, it must be stated that this method can be a cheap and straightforward alternative to official depth measurements.
- From skippers and some vessel owner it is often heard that they find the price of equipment too high compared to their usefulness in day to day operations. Besides some older skippers are hesitating in extra effort to learn how to handle the electronic devices. This stresses that importance of the following topics in the further development of the EconomyPlanner:
    - Ease of use for the different user groups.
    - Value for money – introduction should be guided via showcases in which the value of this application shows.

Although there are many obstacles to be taken, the added value of the EconomyPlanner for Danube vessels and the Danube waterway looks promising. The EconomyPlanner can be made a success if real-time waterway information is provided to skippers in an easy to use setup. There is a lot to do in order to achieve this; a challenging perspective for a service worth the efforts!

3.4. WP4: Power

In this work package possibilities were investigated related to improvements by focusing on the power configurations and assessing how these configurations match the ship's operational profile.

The suitability of different power configurations iss assessed by the means of dynamic modelling. The ships which are in the focus are: Dunaföldvár and Veerhaven X:

- Regarding Dunaföldvár, measurements of one voyage were done and actions are proposed to improve the vessel's performance.
- Regarding Veerhaven X, the results of exhaust emissions measurements haven been collected and analysed. A model is introduced in order to calculate these over one typical journey. This provides basics for further investigation of alternative power configurations. In total, ten alternative power configurations have been proposed. The alternative configurations have been selected according to the vessel's operational profile and include: diesel direct, diesel electric, gas electric, and hybrid power propulsion.

Results of the report provide valuable insight in the current performance of the investigated ships and give the input for future modelling and analysis of the alternative power configurations. The performance of Dunaföldvár could be improved for 20-40% just by selecting another engine and gearbox. On the other hand, the performance of Veerhaven X is in line with its operational profile and within the current exhaust limitations. However, even Veerhaven X might have a problem to meet the future emission requirements and some of the alternative configurations might be a solution for this problem. This report suggests that radical changes in the power configuration and/or implementation of exhaust after treatment devices will be necessary if the proposed emission limitations become effective. It is foreseeable that the future new build vessels will be more constructed with the gas power configurations while the current vessels will have to install after treatment devices to meet the future requirements.

Below some facts and figures concerning the analysis of the performance of the Veerhaven X.

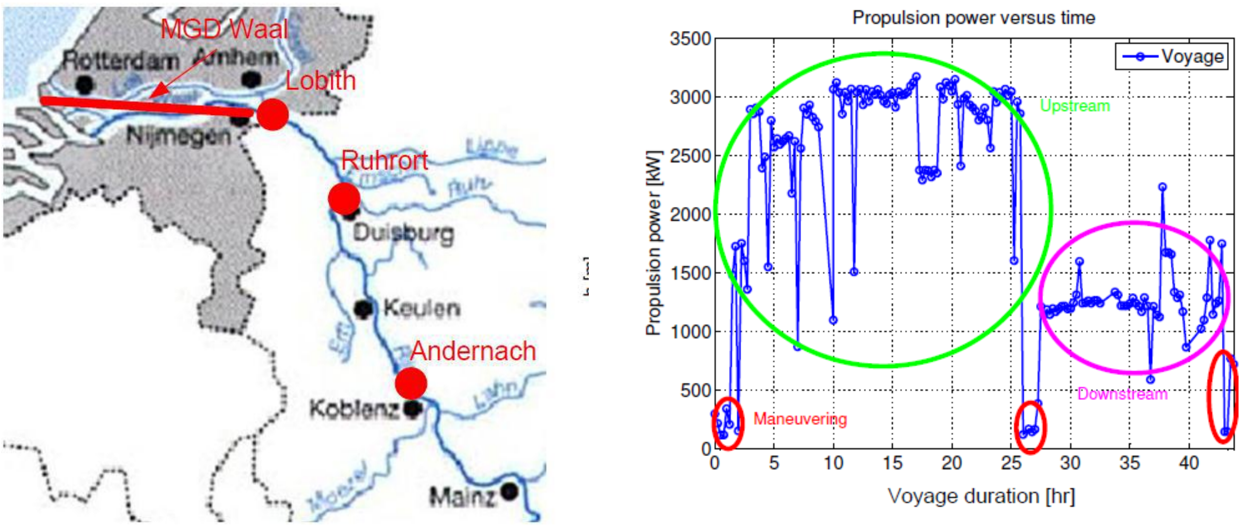

Figure 9: Region of operation (left) and power demand during one journet (right)

Measurements of operational profile of one case-study (TK-Veerhaven VHX) ship are available. These measurements present data collected through six months of sailing voyages from

Rotterdam to Duisburg and back. Furthermore, an operational profile is (probabilistically) build up from sub-profiles like manoeuvring, upstream sailing, downstream sailing.

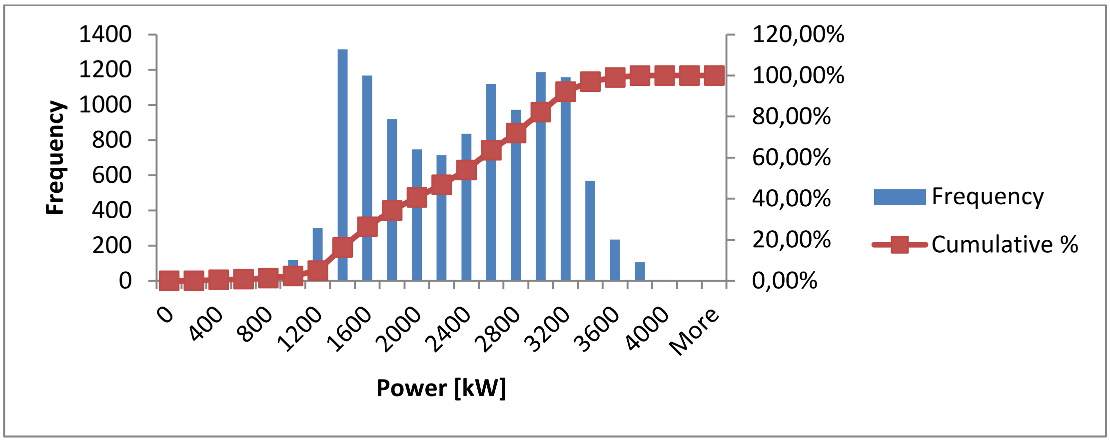

Figure 10: Power distribution of TK-Veerhaven VHX during six months of sailing on the river Rhein

Figure 3 shows power distribution of VHX during six months of sailing. As it can been seen, only small part of time the ship sails with full power 4080 kW. Most of the time the ship sails with power settings **between 40% and 75% of full power. In Figure 4 operational profile is divided into three different** operational modes: manoeuvring, sailing upstream, and sailing downstream.

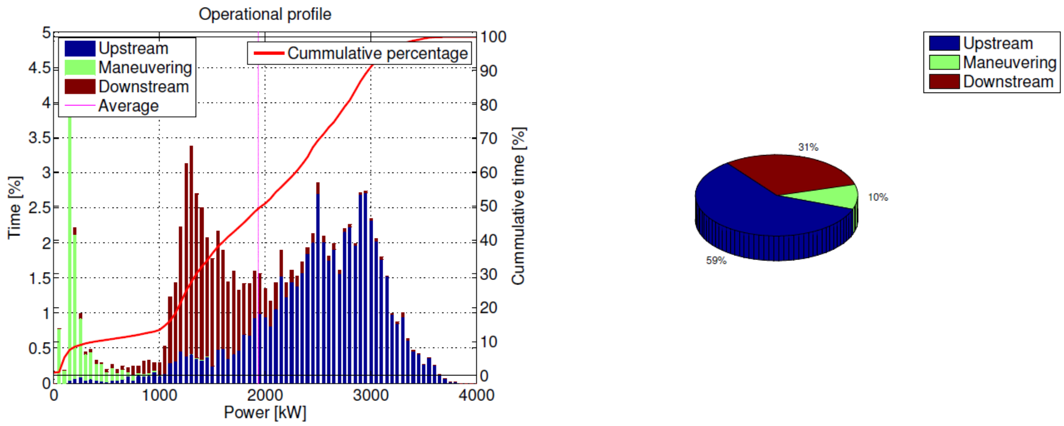

Figure 11: Operational profile of 73 voyages of TK-Veerhaven VHX during six months of sailing on the river Rhein: power distribution (left), total time spent per operational mode (right)

Figure 5 shows comparison of recorded water levels and transport efficiency per voyage. The transport efficiency is indicated in litters of fuel spend per ton transported from Rotterdam to Duisburg.

3.5. WP5: Structures & Weight

The aim of WP5 is to find feasible solutions for:

- Lengthening of an existing inland navigation vessel,
- Conversion of a single hull tanker to a double hull tanker (according to ADN rules).

The operators of inland water vessel have to deal with long periods of low water levels caused by long periods of dryness as well as with renewed rules and requirements for their vessels. Ship lengthening makes it possible to reduce the draft without reducing the payload.

Due to upcoming new ADN regulations, a double hull structure will be mandatory after 2018 for all inland water vessels transporting dangerous goods. A large part of these vessels have currently a single hull structure and cannot therefore be used after 2018. To allow further use, the ships have to be retrofitted with a double hull or they will have to be used for other types of services.

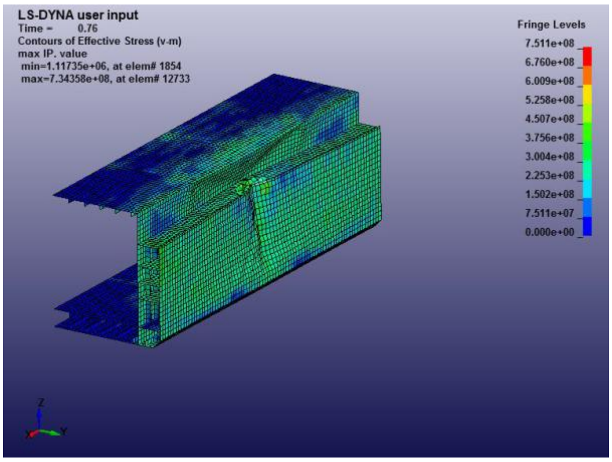

Figure 12: Double hull collision simulation

Additionally, potential lengthening scenarios for inland navigation vessels are examined regarding the enlargement of cargo capacity and the reduction of draught to increase the operating time of the ship.
Besides a conventional steel solution for the single-to-double-hull conversion and the lengthening, multiple options is investigated.

Two inland navigation vessels in need of modernisation haven been selected to serve as reference cases, a single hull tanker MS “Internautik 1” (L_{OA} = 80.0 m) which has been built at Bayerische Schiffbau GmbH in 1968 for the single-to-double-hull implementation and a double hull non-propelled push barge “T 1500” (L_{OA} = 70.0 m), commonly used on the Romanian section of the Danube, for the lengthening investigations respectively.

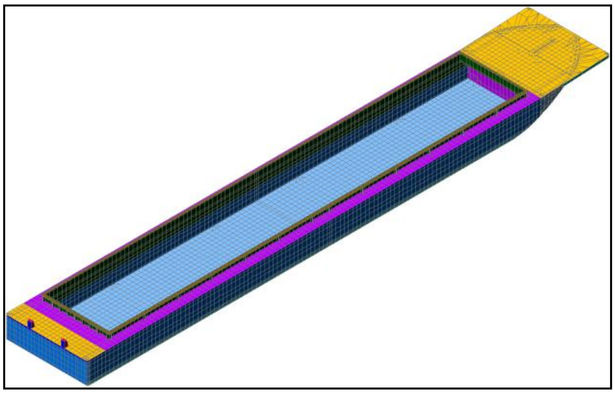

Figure 13: Non-propelled push barge "T 1500"

The results from the analysis show the benefit of the adapted double hull structure compared to the single hull in terms of crashworthiness. Moreover, the weight of the added steel structure and the design is determined. The parameter crashworthiness, set as the amount of absorbed energy per time, is defined for both, single and double hull, and served as benchmark for further material and design solutions.

The achievements of the lengthening of the selected ship reveal the actual structural strength and material scantling for a typical aged inland waterway cargo vessel. The designs as well as the material scantlings are evaluated for the current as built structures. An optimised structure in terms of lengthening has been calculated and evaluated showing the required scantlings of the structures. In brief, the general feasibility of the lengthening was investigated.

From a technical point of view the suggested solutions are feasible considering global and local strength of the hull with some minor issues which can be solved. Different approaches are presented for the single-to-double hull retrofit:

- Steel/polymer-foam/steel double side, considering an inner steel shell which is adhesively bonded to a polymer-foam core to create a sandwich structure.
- λ-shape double side, considering an inner steel shell and a corrugated steel plating acting as foldable core in case of a side impact.
- Rubber bags, implemented into the existing steel hull with the aid of polystyrene blocks as supports.

The subsequent developments are made for the composite lengthening of an inland navigation vessel cargo hold:

- Composite section made of either solid glass fibre reinforced plastics or carbon fibre reinforced plastics.
- Composite section made of either glass fibre reinforced sandwich or carbon fibre reinforced sandwich structures.

The conducted assessment of production techniques and corresponding economic evaluation of different single-to-double hull and lengthening retrofit variants indicate the general feasibility of the innovative structures.

Basic production techniques for the steel/polymer-foam/steel variant are elaborated resulting in relatively high costs without remarkable benefits in comparison to the ADN steel double hull. However, the manufacturing is recognised to be feasible in principle, but is has to be kept in mind that the processing of foam and adhesives on small steel shipyards will entail difficulties.

As second innovative retrofit solution, the λ-shape steel double hull is developed, avoiding any plastics or composite parts. Welding sequences for the production and implementation of the steel panels are introduced. Here as well, the production of the structures is feasible in principle, although small closed spaces are involved (λ-shape side structures). The processing of the λ-shape structures can be integrated in the conventional production processes on a common steel shipyard.

Using fibre reinforced rubber bags for the carriage of liquid dangerous goods onboard inland navigation vessels is a completely new idea and differs most from the present rules and regulations from classification societies and other authorities. On the other hand, the implementation of the prefabricated bag supporting devices (panels or polystyrene blocks) and the bags themselves into the existing hull is very simple and efficient. The time in the shipyard for conversion can be reduced to a minimum resulting in a low loss of returns in that period. Additionally, the rubber bags can be exchanged very quickly depending on their wear and alternating cargo.
The involved costs for the conversion of the rubber bag variant are currently the highest due to the high costs of the rubber bags, but the economic assessment shows the potential of that solution in terms of efficiency (high cargo carrying capacity and simple components involved). The rubber bag solution is superior to the other considered double hull solutions, including the basic ADN steel double hull. Benefits in comparison to the ADN solution range from 20 % (scenario 3: high freight rate) to over 50 % (scenario 1: low freight rate). In the current state, the steel/polymer-foam/steel variant is always inferior compared with the ADN steel double hull retrofit caused by expensive adhesive and polymer-foam components. The λ-shape structures offer similar benefits at the high freight rate scenario 3.
The payback periods within the three different scenarios for the single-to-double hull retrofit solutions range from 11.9 to 18.0 years (scenario 1: low freight rate), 7.1 to 10.7 years (scenario 2: medium freight rate) and 5.1 to 7.6 years (scenario 3: high freight rate).

A major obstruction of implementing alternative constructions and uncommon materials on inland navigation vessels are the current prescriptive rules and regulations published by classification societies and national and European authorities. Hence, those rules provide a strict and conservative approach for the design and construction of the ships.

Considering unconventional materials such as foams or plastics on-board ships, the influence of fire is a major concern of the classification societies and authorities. However, recent implementations of composites into ships as superstructures, other components or even complete vessels have been built from composites. Extensive risk analyses for the novel technologies and structures have been conducted at the Swedish shipyard Kockums for instance which evidences that the application of composites in shipbuilding industry is increasingly respected. As the loads on inland navigation vessels are much smaller in general as on sea-going ships, the implementation of novel materials and structures should be driven in a more proactive manner to improve the efficiency of the fleet.

3.6. WP6: New scales & services

In WP6 – New scales & services - some of the actions that could be undertaken in order to improve market position of existing vessels were evaluated. The focus was on vessels that are either small (i.e. length of the vessel is < 86 m) and thus are losing market share to the larger vessels, or on vessels faced with new market conditions (climate change effects, new types of cargo, new regulations).

Lengthening of the mid-body (new scales) is recognized as a technical measure that should lead to enhancement of economic competitiveness of the small vessels. Extension of the hull is already present in the shipbuilding practice, however the effects and implications of such practices were not thoroughly analysed so far. Therefore, WP6 aims to provide an engineering analysis of insertion of large sections in the mid-ship area with respect to:

1. The strength of extended hulls (Task 6.3).
2. Manoeuvrability (Task 6.2) and
3. (re)Powering of lengthened vessels (Task 6.3).

4. The results of these technical aspects (1- 3) were used in an assessment of the overall economic benefits of lengthening. The abovementioned analysis is carried out in several steps so that trends and consequently, critical lengths, could be established.

Apart from, lengthening the following topics were researched;

5. Effective technical solutions for navigation in low water level periods (Task 6.5).
6. Available options for transport of CO2 (new cargoes) and technical conditions that need to be met were researched. This should result in ready-made solutions for a market that is already “on the horizon” (Task 6.6)..
7. Detecting new markets for single hull tankers that are to be phased-out due to the new ADN regulations . (Task 6.7).

This research resulted in a set of business cases from which it is clear if, and how ships can deployed in an economically sound way in new situations.

Although results of the analysis heavily depend on assumed operational scenarios, the findings of WP6 – New scales & services are the following:

1. It was shown (Tasks 6.1 to 6.4) that it would be technically feasible to lengthen the CEMT class III/IV vessel “Hendrik” by as much as 18m (from LOA=70m to LOA=88m). Although the manoeuvrability of the vessel was not drastically affected by the lengthening, the evasive manoeuvre tests revealed that a new, improved rudder arrangement would be required. Replacement of engine by a modern, cleaner and lighter one was considered as well. The payback periods were found to be relatively short, thus confirming the viability of this retrofit solution for vessels operating on a short distance route on the Rhine on a regular basis. Moreover, analysis also demonstrated that there are conditions related to waterway characteristics and economic environment under which the lengthening would not pay off, even though it would be technically feasible. Payback periods corresponding to the lengthening of the CEMT class II vessel “Rheinland” by 12m (from LOA=57.5m to LOA=69.5m), operating on a long distance route on the Danube in the less favourable economic conditions, were found to be too long. Both examples have shown that greater benefits – economical and environmental – are

achieved by a proper combination of retrofit options by reducing the power demand of the lengthened ship (for instance, by installing propeller in a nozzle which in most cases did not extend the payback period).

2. The analysis of Task 6.5 (Adjustment to climate change) has shown that climate change will on the long term (after 2050) result in substantially longer periods of low water causing capacity and operating costs impacts for the IWT sector. For the first half of the 21st century, however, the time horizon for retrofit options as assessed in MoVeIT!, impacts from various climate scenarios are fairly limited. It is recommended therefore: a) to assess installation of adjustable tunnels on large ships operating on the Rhine, and b) explore the availability of second-hand barges that would suit coupled convoy operations.
3. Regarding the potential market for CO_2 transport (Task 6.6 – Adaptation to CO_2 transport) it was concluded that the transport costs for an adapted 110m inland vessel, sailing between a power plant (typically in Germany or Holland alocated on the Rhine) and a seaport over distance of 600 km, are approximately 20 EUR/tonne CO_2. These transport costs rise to approximately 30 to 40 EUR per tonne CO_2 when liquefaction and offshore transport to a storage field with sea-going ships are considered. Compared with the current prices of CER (Certified Emission Reduction units), it is clear that the transport of CO_2 with inland ships is, at the time, economically not feasible.

3.7. WP7: System integration & assessment

In WP7 all improvement options that are researched in the project were brought together. This consolidation has been performed in three steps;

1. Collect and integrate feasible options for modernisation.
2. Assess the economic viability of these solutions/designs.
3. Analyse and determine the environmental performance of the designs

Options for modernisation

In WP7.1, the various options for modernization worked out. All inputs from WP2 to 6 are collected and for the 5 reference cases it is researched how they can best be implemented on existing ship designs. All inputs were assessed in terms of cost, economic benefits, environmental benefits and safety (ADN related) benefits. The most promising combinations of modernization options will be elaborated and implemented into at least three technically feasible designs per case.

For 5 ships it is researched in detail how these generic solutions affect the performance of these specific ships. These vessels are the push boats Dunaföldvar, Inflexible & Veerhaven X and the cargo ships Herso I and Carpe Diem.

	Retrofit option	Investments (€)	Time at yard	Impact in fuel consumption	Impact on ship capacity
Herso 1					
	Lengthening 20%	200.000	4 weeks	+3% to + 5%	310 t
	Trapezes	100.000	2 weeks barge only	-10% to – 15%	N/A
	Ship Studio Solution	40.000	1 week	-10% to – 11%	N/A
Dunaföldvár					
	Shaft generator	50.000	Unknown	No benefit	N/A
	Remove flanking rudders & placement of BT gondola	215.000 – 265.000	3 weeks	-5% to -7%	N/A
	New engines		0 weeks	0%	N/A
Veerhaven X					
	Improvement of stern	N/A	N/A	0%	N/A
	Improvement of bow thrusters gondola	N/A	N/A	0%	N/A
	Installation of SCR	200.000 – 250.000	0 weeks	0%	N/A
Inflexible					
	Waste heat recovery	>> 20.000	1 month?	8.400 to 42.000 kWH/year	N/A
	Removal o strut from propeller nozzles	70.000 – 160.000	4 weeks	-5%	N/A
	Replacement of rudders	200.000 – 320.000	2 weeks	-3% to -4%	N/A
	Ship Studio Solution	260.800	1 week	-13% to -15%	N/A
Carpe Diem					
	Softening of the fore shoulders	N/A	N/A	0%	N/A
	2-rudder solution	200.000 – 320.000	2 weeks	-3% to -4%	N/A
	Removal/shortening of gondola	160.000	4 weeks	0% to -3%	N/A

Table 1: Overview of assessed retrofit options

Based on the analysis carried out the following recommendations can be made:

1. Retrofit options relating to propeller improvements are feasible options and many European vessels will benefit of such improvements. A wider application of these kinds of retrofit options is desirable, as investment costs are reasonable compared to possible fuel reductions.
2. For smaller vessels lengthening seems to be a feasible option as the option increase the cargo carrying capacity of the vessel against an almost negligible increase in fuel consumption. This retrofit option could be applied widely on smaller vessels.
3. The installation of new engines is a feasible option, as fuel consumption can be reduced and in some cases it could enable vessels to transport more cargo. A reduction in fuel consumption will reduce the level of CO_2 emissions. However it should be analysed what

the impact the new engines is on the level of other emissions. It might well be that the emissions levels of for instance NOx and PM might increase.

4. Some of the options considered for the five vessels participating in the consortium are not feasible for the analysed vessels; however they might be feasible for less advanced vessels than the ones considered in MoVe IT!! It is desirable to analyse these retrofit options further, as they might be feasible options for other vessels or vessel types.

The primary lessons learned from the work package are:

1) *There is no single best solution for everyone.* All ships are different, all owners are different and the way each ship is used is different. So it is not possible to simply copy what someone else is doing. Each ship owner or shipbuilder should think about what would be the best option for the specific ship under consideration.

2) *Be careful how you spend your money.* There are a lot of ways to reduce a ship’s fuel consumption, but it is always important to check if the cost of a solution is not higher than the benefits. MoVe IT! discovered that there are a lot of cases where an improvement simply doesn’t earn itself back fast enough.

3) *Always check how certain the provider of an improvement is of the benefits.* For some improvements, it is hard to predict how well they work in practice, no matter how many tests or calculations are performed. So make sure to always ask what the worst and best case scenarios are and discuss what will happen if the improvement doesn’t work as well as promised. Does the owner earn back his investment?

4) *Talk about it!* In MoVe IT! we learned that almost every ship can be improved and there are usually more ways to do this than you know. The best way to find out what the options are is to talk to the experts, who can usually provide first advise at little or no cost.

3.8. WP8: Demonstrators

Service quality, cost efficiency and environmental friendliness are the main pillars of a modern transportation system. The EU project MoVe IT! (www.moveit-fp7.eu) contributes to these pillars by research and development focussed on modernisation of inland waterway vessels by retrofitting. A great number of different technical options was identified, having a positive impact on the economic and environmental performance of inland waterway transport. In order to stimulate an implementation of the results by the industry, visualisation of the positive impacts in a way easily to be understood was realised by a set of vivid demonstrators, being described in the following. The demonstrations conducted are documented by concise reports and animations to be accessed via the project website. The animations are available also at YouTube.

Generally speaking, demonstrators are prototypes that help turn an idea into a real, practical implementation. With the help of demonstrators, reliable performance of a concept and / or individual development will step the way to market capability and operational suitability will be demonstrated. In MoVe IT! the demonstrators were associated with the following objectives:

- Show that the implementation of the technologies under consideration is possible under real-life conditions;
- Visualize the effects associated with a certain dedicated technology implementation;
- Show qualitatively the achievement of the performance improvements expected;
- Show quantitatively the achievement of the performance improvements expected.

In order to achieve maximum impact, three different kinds of demonstrators were realised in MoVe IT!:

- 8.1 Demonstrations by simulators, showing the effects of different rudders, ship lengthening, removal of flanking rudders and installation of a bow thruster, as well as the so-called “pump propeller”;
- 8.2 Demonstrations of part solutions, showing the effects of different hydrodynamic improvements by CFD (Computational Fluid Dynamics), structural solutions by FEM (Finite Element Method) and experimental tests as well as the creation of an “actual local water depth chart” based on cooperative depth measurements;
- 8.3 Demonstrations of full solutions, showing how the EconomyPlanner application for mobile devices works, as well as which improvements can be achieved by hydrogen injection applied to a marine combustion engine.

The ten demonstrations performed gave a variety of results which are summarised in the following:

- Different rudder designs can result in different results regarding fuel consumption. Using new designs, fuel savings around 8 per cent can be achieved, and the manoeuvring capabilities may remain still satisfactory;
- Removal of flanking rudders can result in reduced fuel consumption. Sufficient manoeuvrability can be maintained by installation of a bow thruster with sufficiently high power;
- Ship lengthening in association with constant payload, as well as constant draught can be beneficial with respect to the relative fuel consumption of a vessel, resulting in a decreased , however, still sufficient manoeuvrability;

- The application of the so-called “pump propeller” leads to improved manoeuvrability;
- It is possible to create an “actual local water depth chart” with the help of a standard depth gauge on board of a limited number of inland ships navigating in a certain area. It is possible to provide this information including a determination of the shallowest part on the stretch sailed via a mobile device;
- With proper hull-form optimisation a significant reduction in fuel consumption can be achieved. Further, the realisation of unfavourable modifications resulting in unnecessarily higher fuel consumption can be prevented in advance;
- Several safe structural solutions, performing almost equally with respect to kinetic energy absorption and time to full energy absorption, are available: ADN steel double hull; λ-shape steel double hull; Y-shape steel double hull, whereby the λ-shape or Y-shape steel double hulls indicate the potential to minimise the double hull width, offering bigger cargo-holds and higher economic efficiency;
- A steel-foam-steel sandwich double-bottom structure leads to a significant improvement with respect to deformations due to a possible grounding event;
- Application of hydrogen injection can lead to compliance of a CCNR 0 engine (construction year 1999) with the CCNR II emission standard.

4. Dissemination and exploitation, impact of MoVe IT!

4.1. Impact

The MoVe IT! Project aimed at a modernisation of inland waterway vessels with focus on retrofitting of existing vessels and technology transfer from new buildings and other transport modes. Improving the environmental performance of the vessels considered is one major objective of the project. Therefore, the environmental assessment plays an important role in the evaluation of the technologies developed, with respect to their practical application.

Based on consultation with experts and, in particular, the representatives of the ship owners of the project, a number of retrofit solutions regarded as worth to be investigated further with respect to their practical implementation were identified. The solutions were subjected to an environmental assessment, carried out for five vessels, comprising a container vessel, three pushers and a motor cargo vessel being operated together with a lighter. The emissions considered comprise the CO2, NOX, PM, HC, CO and SO2 emissions. The emissions are estimated using the fuel consumption recorded, as well as emission factors related to the mass of fuel. The emissions are presented as yearly values, and values related to the transport performance in tonne kilometres (tkm). The effects of the different technologies to be applied in the vessels are taken into account by the resulting reduction of the fuel consumption or directly by the reduction of the respective emissions in per cent. The emissions referred to tkm are compared with the ones of road transport carried out with trucks complying with emission standards EURO III up to Euro VI, as well as the East European emission standard (EE).

On European level, the yearly total emissions of the EU fleet are considered. Due to their significance in the evaluation of the external costs caused by air pollutants and greenhouse gasses, and the current discussion on stricter emission standards for inland waterway transport (IWT), only the CO2, NOX and PM emissions are taken into account. The reduction in the yearly emissions of the EU fleet as well as the associated reduction in the external costs is evaluated. The analysis on European level is based on Panteia (2013), where the impact of a variety of policy options for improving the environmental performance of the EU fleet was analysed, including a comprehensive cost-benefit analysis.

The emission factors for IWT can differ significantly, depending on the source used. For plausible estimation of the emissions of an inland waterway vessel, it is necessary to consider the power class of the vessel, in addition to the construction year and operation (full load, part load) of the engine. In ship-specific cases, the usage of average values can lead to completely different results, and therefore, the usage of average emission factors derived for a fleet has to be critically evaluated to determine whether this is suitable if a certain vessel is to be investigated. However, for considerations performed on a macro level e.g. EU fleet or national fleet, the usage of average emissions factors is state of the art, and it seems to be a valid option as it cannot be expected that for each vessel of e.g. 10 000 vessels the emissions will be exactly estimated and summed up.

4.2. Benefits of retrofits on EU level

The evaluation of the impact of applying the MoVe IT! technologies to the EU fleet is performed considering the external costs caused by the air pollutants NOX and PM, as well as the greenhouse gas CO2. The technologies have different impacts on the CO2, NOX and PM emissions. Some have a noticeable impact on CO_2 emissions, others have a noticeable impact on NOX or PM emissions.

From the point of view of a ship owner, assuming that there is no incentive or regulative pressure to invest in devices for reduction of NOX emissions, the reduction in fuel consumption and CO_2 emissions is most likely of greater importance as the operational costs may be reduced and a part of the investment costs may be recovered.
However, from the point of view of the society, a significant reduction of NOX emissions may be more important. The significance of the different emission types is described by the costs they cause to the society, called external costs. Using the reduction in external costs associated with the application of the different technologies considered, a comparison can be made with respect to the choice of the technology with the greatest impact on the costs to the society.
This information can be used also as reference for the evaluation of the order of magnitude of possible incentives to be provided for the implementation of promising technologies.

In 2012, the external costs caused by the CO_2, the NOX and the PM emissions of the majority of the EU fleet are estimated as 450, 1 200 and 550 Mio EUR (Panteia, 2013). A 50 % reduction in specific fuel consumption, which however is extremely difficult to achieve, if at all, is equivalent to a reduction of approximately 100 % of NOX emissions, from the point of view of external costs. With respect to the MoVe IT! technologies considered, the greatest impact on the reduction of the external costs is achieved by usage of a new engine of CCNR 2 standard, combined with SCR and PM filters. The reduction in external costs accounts for approximately 1 500 Mio EUR per year, corresponding to an approximately 75 % reduction of the total external costs caused by the CO_2, NOX and PM emissions. Also very effective is the application of SCR and PM filters to existing engines. The cause for the effective reduction in the external costs is the reduction in NOX and PM emissions. It is noted that the technologies to be applied shall not be limited to SCR and PM filters. Other technologies may have a similar potential for reduction of the NOX and PM emissions. Most important is to achieve a significant reduction in these emissions.

Important to note is also that retrofitting an existing engine with a new technology may be considered as major conversion, demanding compliance with the most recent emission standards in force, which might not be achieved in the case the emission standards are very stringent (e.g. possibly starting from 2016), depending on the technology. The result will be that the engine cannot be retrofitted, although there would be a significant benefit to the society, still.

When considering the technologies with significant impact on the reduction of NOX and PM emissions e.g. SCR (Selective Catalytic Reduction - is an advanced active emissions control technology system that injects a liquid-reductant agent through a special catalyst into the exhaust stream of a diesel engine) and PM filters, the reduction in external costs per year and vessel may amount to approximately 150 000 EUR on average. Again, it is stressed that this value is an average value. The real value associated with a particular vessel can deviate significantly from the average. However, the reduction in the average costs presented is certainly a good indication for the meaningfulness of providing proper incentives to the ship owners for the implementation of technologies with a significant impact on the reduction of NOX and PM emissions, e.g. but not limited to SCR, PM filters or/and new engines.

4.3. Demonstrators

Service quality, cost efficiency and environmental friendliness are the main pillars of a modern transportation system. The EU project MoVe IT! (www.moveit-fp7.eu) contributes to these pillars by research and development focussed on modernisation of inland waterway vessels by retrofitting. A great number of different technical options was identified, having a positive impact on the economic and environmental performance of inland waterway transport. In order to stimulate an implementation of the results by the industry, visualization of the positive impacts in a way easily to be understood is realised by a set of vivid demonstrators.

Generally speaking, demonstrators are prototypes that help turn an idea into a real, practical implementation. With the help of demonstrators, reliable performance of a concept and / or individual development will step the way to market capability and operational suitability will be demonstrated.

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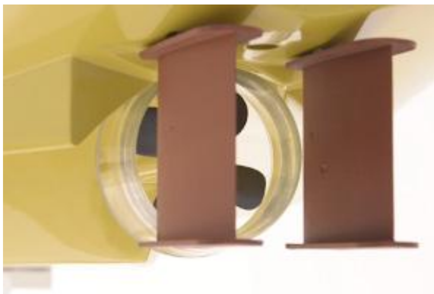
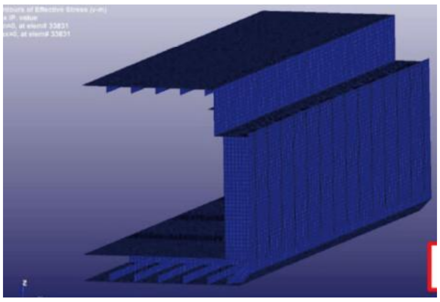
In order to achieve maximum impact, three different kinds of demonstrators are realized in MoVe IT!:

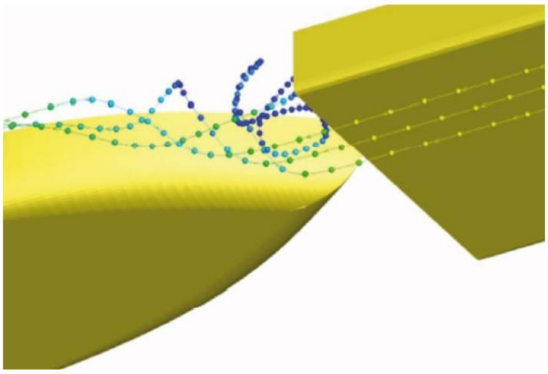


1. Demonstrations by simulators;
    - the effect of rudder configurations on fuel consumptions (top right)
    - the effect of removing flanking rudders including the option of applying lateral thrusters in the bow of a push-boat to compensate loss of backward steering capacity,
    - the effects of ship lengthening in order to maintain loading capacity in shallow water periods (middle right),
    - the effect of different retrofit measures applied on the HERSO 1.

2. Demonstrations of part solutions;
    - the possibilities of cooperative depth measurements
    - animations of impact of collisions on vessels with different double hull structures
      (hull structure, bottom right)



- animations of the application of Computational Fluid Dynamics in optimizing the hull, rudders and propellers of vessels.



3. Demonstrations of full solutions;
    - A mobile application that provides basic features of the economy planner:
      the location and the water depth of the shallowest point on the river.
    - how hydrogen injection in the combustion chamber of a vessel (a ThyssenKrupp pushboat) can lead to an improved combustion process, in turn reducing exhaust gas emissions such as NOX and PM.

For detailed descriptions of each demonstration performed and contact information of the respective responsible person consult the WP8 reports available for download on the MoVe IT! project website: www.moveit-fp7.eu.

4.4. Dissemination

In 2014 MoVeIT! has been presented at several events, conferences and meetings:

4.4.1. Maritime Industry

Maritime Industry is an annual three-days' event for the maritime industry in Gorinchem (the Netherlands) and especially attended by ship-owners and suppliers of marine equipment. At this year's edition MoVeIT! partners SPB/EICB and MARIN both had stands, in which attendants could ask questions about amongst others the MoVeIT! project. At the first day of the Maritime Industry event (13 May) MoVeIT! was presented in a meeting for ship-owners, maritime suppliers and other interested visitors with three presentations:

- Introduction of the MoVeIT! project and EconomyPlanner, Meeuwis van Wirdum (MARIN)
- Analysis of hydrodynamic performance, Karola van der Meij (MARIN)
- Feasible and affordable solutions, Robert Hekkenberg (Delft University of Technology).

These presentations were meant to give a quick overview of the project for especially the end-user. After the introduction of the project by the project leader, it showed the possibilities of energy-efficient operations and the future possibilities to use (collective) data for this. The presentations thereafter gave an impression of the analysis of the hydrodynamic performance of vessels and how to come to economic and technological feasible solutions and giving case-by-case an overviews of feasible options.

4.4.2. PIANC World Congress

At the world congress of PIANC, the World Association for Waterborne Transport Infrastructure, two presentations were given about research performed within the MoVeIT! project. The 33rd PIANC World Congress were held from 1 to 5 June in San Francisco. This congress is a worldwide event which targets mainly an academic and governmental (waterway authorities) public. For this, presentations given with regards to MoVeIT! research were:

- "Evaluation of a one-year operational profile of a Danube vessel" by Juha Schweighofer (Via Donau) and Béla Szalma (Plimsoll)
- "Pilot water depth measurements by the commercial fleet" by Meeuwis van Wirdum (MARIN)

4.4.3. Final Event / EIWN Conference

On Thursday 11 September, the MoVeIT! consortium presented its findings of the research performed on cost-effective modernisation of the inland waterway fleet. This final event was organised in combination with the European Inland Waterway Navigation (EIWN) conference in Budapest, in which also the recent developments in the IWT sector are presented. During the Final Event presentations were given by:

- Introduction to the MoVeIT! project, Meeuwis van Wirdum (MARIN)
- Performance measurement of European inland ships, Karola van der Meij (MARIN) and Milinko Godjevac (TU Delft)
- EconomyPlanner, optimal use of inland waterways, Arno Bons (MARIN)

- Development of novel structures for the retrofit of inland navigation vessels, Lars Molter (Center of Maritime Technologies e.V.)
- Extending the life of a ship by extending her length, Igor Bačkalov (University of Belgrade)
- Retrofit solutions for inland ships, Robert Hekkenberg (TU Delft) and Cornel Thill (DST)
- Environmental and economic analysis of the MoVeIT! vessels, Juha Schweighofer (via donau) and Johan Gille (Ecorys)
- Guidelines on possible solutions for ship-owners, Cornel Thill (DST).

The presentations given during the final event were selected to give a comprehensive impression of the research performed within the MoVeIT! project and the results of this research. The final event started with a short introduction of the project by Meeuwis van Wirdum, project coordinator of MoVeIT!. After this, presentations were given about the several topics researched within the MoVeIT! project. Milinko Godjevac (Delft University of Technology) and Karola van der Meij (MARIN) presented the performance of the five vessels, with speed trail and operational profile measurements. Arno Bons (MARIN) presented the concept of the EconomyPlanner and the opportunities to use this for a more efficient use of the waterways, starting with the collaborative water depth measurements. Lars Molter (CMT) gave a presentation on structural challenges with a focus on the double-hull retrofit. One of the other structural challenges, the lengthening of an inland vessel and its technical and economic assessment were presented by Igor Bačkalov (University of Belgrade). In their presentation Robert Hekkenberg (Delft University of Technology) and Cornel Thill (DST) gave an overview of the retrofit solutions, the system integration of them and the hydrodynamics. Juha Schweighofer (via donau) and Johan Gille (Ecorys) addressed the results of the economic and environmental assessments performed on the retrofit solutions. In the final presentation Cornel Thill presented the guidelines that will be published on the solutions researched within the MoVeIT! project and can be used by ship-owners to get an impression of relevant retrofit solutions.

7th European Inland Waterway Navigation Conference, 10-12 September, Budapest, Hungary

Next to the presentations at the final event, several presentations were given at the EIWN conference by the MoVeIT! partners Budapest University of Technology and Economics, MARIN, Delft University of Technology, University of Belgrade, via donau, DST, Ship Design Group and SPB / EICB. Three of these presentations focussed also directly on research performed within the MoVeIT! project:

- Promising hydrodynamic improvements, by Karola van der Meij (MARIN)
- CoVadem: cooperative data solutions for IWT, by Meeuwis van Wirdum (MARIN)
- Grounding demo tests, by Ionel Chirica (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP)

4.4.4. Other events

Besides, MoVeIT! was presented during several other occasions in 2014:

1. Közlekedéstudományi Konferencia (Conference of Transport Sciences) Győr 2014, 27-28 March Győr, Hungary.
   Presentation by Budapest University of Technology and Economics on the MoVeIT! project and the retrofitting solutions.

2. Society of Naval Architects of Serbia Meeting, 31 March, Belgrade, Serbia.
   Presentation by University of Belgrade, MARIN, Delft University Technology

3. VBW (Association for European Inland Navigation and Waterways), Spring 2014, Duisburg, Germany.
   Presentation on the operational results and effects of retrofitting by DST

4. 5th Transport Research Arena Conference, 16 April, Paris, France
   MoVeIT! – Modernisation of the existing European IWT Fleet, by Linette de Swart and Johan Gille (Ecorys)

5. General Assembly of the Romanian Association of Shipbuilders, ANCONAV 58-General Assembly, 14.05.2014, Mamaia, Romania.
   MoVeIT! – Modernisation of Vessels for Inland waterway freight Transport. Results Obtained by Romanian Partners SDG and UGAL, by Ionel Chirica (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP)

6. International Conference on Maritime Technology, 7-9 July 2014, Glasgow.
   Power configurations of an inland pusher, by Milinko Godjevac (Delft University of Technology

7. The Twenty-second Annual International Conference on Composites/nano Engineering (ICCE-22) ICCE-22 July 13-19, 2014 Malta.
   Grounding Simulations of Ship Hull Sandwich Structure, by Ionel Chirica, Elena-Felicia Beznea, Ionel Gavrilescu (University Dunarea de Jos of Galati) and Vasile Giuglea, (SHIP DESIGN GROUP)

8. The 12-th International Conference on Marine Sciences and Technologies, BLACK 2014, 25-28.09.2014, Varna, Bulgaria.
   Influence of the Inland Ship Lengthening on the Cargo Capacity, by Ionel Chirica, Elena-Felicia Beznea (University Dunarea de Jos of Galati) and Ovidiu Ionas (SHIP DESIGN GROUP Galati, Romania)

9. Ship Hull Retrofitting Influence on the Manoeuvring Performances, by Ionel Chirica, Elena-Felicia Beznea (University Dunarea de Jos of Galati) and Stefan Giuglea (SHIP DESIGN GROUP) .
   Maritime Activities in Romania (with presentation of MOVE It! Project), by Ionel Chirica (University Dunarea de Jos of Galati)

10. The 24th International Workshop on Computational Micromechanics of Materials (IWCMM24), October 1-3, 2014, IMDEA Madrid, Spain.

Ship Hull Sandwich Structures Response to impact, by Ionel Chirica, Ionel Gavrilescu (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP)

11. General Assembly of the Romanian Association of Shipbuilders, ANCONAV 59-General Assembly, 12.09.2014, Mamaia, Romania.
    Inland Ships Grounding Simulations Performed within FP7 Project MOVE IT!, by Stefan Giuglea (SHIP DESIGN GROUP), Ionel Chirica (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP)

12. Royal Institution of Naval Architects Conference on EEDI, 24 September 2014, London.
    Energy Efficiency of Inland Waterway Self-Propelled Cargo Ships, Aleksander Simić (University of Belgrade)

13. First edition of the exhibition UGAL INVENT 2014, University Dunarea de Jos of Galati Romania, 08-10 October 2014.

    Poster presentation of Numerical Simulations of the Ship Structure's Impact by Ionel Chirica, Ionel Gavrilescu, Elena-Felicia Beznea, Florentina Rotaru (Paraschiv), (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP)

    Poster presentation of Increasing the Cargo Capacity by Ship Lengthening by Ionel Chirica (University Dunarea de Jos of Galati) and Ovidiu Ionas, Octavian Dumitriu (SHIP DESIGN GROUP)

14. Inland Navigation Congress of the Austrian Society for Transport Sciences, 13 November 2014, Vienna, Austria
    Presentation on WP7: The Inland Waterway Vessel – A Modern Means of Transportation – Technical Aspects (economic and environmental analysis), by Juha Schweighofer (Via Donau).

4.4.5 Press

Apart from the own communication channels, the MoVeIT! project and its results and activities were mentioned in the press, varying from (IWT) newspapers and a radio interview:

a. CBRB Info (newsletter of a sector organisation), April 2014: "MoVeIT! onderzoekt de modernisering van de binnenvaartvloot" (MoVeIT! performs research into the modernisation of the inland waterway fleet)
b. CBRB Info, May 2014: "Onderzoek naar de betaalbare modernisering binnenvaartvloot" (Research into affordable modernisation inland waterway fleet)
c. Scheepvaartkrant (Dutch IWT newspaper), 5 May 2014: "Bijeenkomst 'Modernisering Binnenvaart'" (Meeting 'Modernising Inland Waterway Transport')
d. Binnenvaartkrant (Dutch IWT newspaper), 6 May 2014: "Is betaalbare modernisering binnenvaartvloot mogelijk?" (Is affordable modernisation inland waterway fleet possible?)
e. Schuttevaer (Dutch maritime newspaper), 6 May 2014: "Kosteneffectieve modernisering met MoVe IT!" (Cost-effective modernisation with MoVe IT!)
f. Danube News (newsletter via donau), 12 May 2014: "Erste Ausgabe des MoVeIT! Newsletters jetzt verfügbar" / "First edition of the MoVeIT! newsletter now available"
g. Radio Rijnmond (radio broadcaster for Rijnmond region), 13 May 2014: Radio interview with Meeuwis van Wirdum on the modernisation of inland waterway transport and to promote the Maritime Industry meeting

h. BLN (sector organisation), 21 May 2014: “Onderzoek naar betaalbare modernisering binnenvaartvloot” (Research into affordable modernisation inland waterway fleet)
i. CBRB Info, August 2014: “MoVeIT! eindevenement op de EIWN-conferentie op donderdag 11 september” (“MoVeIT! final event at the EIWN conference on Thursday 11 September).
j. Binnenvaartkrant, 26 August 2014: “Op zoek naar betaalbare innovaties met MoVeIT” (Looking for affordable innovations with MoVeIT!)
k. Danube News (newsletter via donau), 8 September 2014: “MoVeIT! Final Event; MoVeIT!: Strategien zur kosteneffizienten Modernisierung der europäischen Binnenschifffahrt” / “MoVeIT! Final Event; MoVeIT!: Options for cost-effective modernisation of the European IWT fleet”
l. Stroming Courant (Dutch IWT newspaper), October 2014: “Conferentie Boedapest: Een blik in de toekomst van de Binnenvaart; Slim zakendoen met handige app” (Conference Budapest: Glance at the future of Inland Waterway Transport; Doing smart business with smart app)
m. EICBulletin (newsletter EICB), October 2014: “Afronding MoVeIT!” (Finalising MoVeIT!)
n. “Viata Libera” (local newspaper Galaţi), 13 October 2014, A picture and an article on the Move-It! research dissemination.

4.4.6 Papers and articles

a. For the mainly scientific dissemination several research papers and scientific articles were published on the research performed within the MoVeIT! project:
b. MoveIt! - Modernisation of Vessels for Inland Waterway Freight Transport, by Ionel Chirica (University Dunarea de Jos of Galati) and Vasile Giuglea (SHIP DESIGN GROUP Galati), in Journal Partnership Maritime Review
c. Energy Efficiency of Inland Waterway Self-Propelled Cargo Ships, by Aleksander Simic (University of Belgrade)
d. Move-IT – modernisation of the existing European IWT fleet, Johan Gille and Linette de Swart (Ecorys)
e. Power configurations of an inland pusher, by Milinko Godjevac (Delft University of Technology)
f. Performance Measurements of European Inland Ships, by M. Godjevac PhD. MSc (Delft University of Technology) and K.H. van der Meij MSc (MARIN)
g. EconomyPlanner; optimal use of inland waterways, by Arno Bons, Kor Molenaar, Meeuwis van Wirdum (MARIN) and Rolien van der Mark (Deltares)
h. Development of novel structures for the retrofit of inland navigation vessels, by Timo Wilcke, Dr. Lars Molter, Dr. Frank Roland (CMT), Dr. Ronald Horn (SMILE-FEM), Dr. Ionel Chirica (UGAL), Erwan Juin (Swerea) and Ovidiu Ionas (SDG)
i. Extending the life of a ship by extending her length: Technical and economic assessment of lengthening of inland vessels, by Igor Bačkalov, Dejan Radojčic (University of Belgrade), Lars Molter, Timo Wilcke (CMT), Karola van der Meij (MARIN), Aleksander Simić (University of Belgrade), Johan Gille (Ecorys)
j. Retrofit solutions for inland ships: the MoVe IT! approach, by Robert G. Hekkenberg (TU Delft) and Cornel Thill (DST)
k. Environmental and economic analysis of the five MoVe IT! Vessels, Juha Schweighofer (via donau), Dávid György, Csaba Hargitai, István Hillier, László Sábitz, Györzö Simongáti (BME), Johan Gille and Linette de Swart (Ecorys)
l. Promising hydrodynamic improvements, by Karola van der Meij and Hoyte C. Raven (MARIN)

m. Evaluation of a one-year operational profile of a Danube vessel, by Juha Schweighofer (Via Donau) and Béla Szalma (Plimsoll)
n. Pilot water depth measurements by the commercial fleet, by Meeuwis van Wirdum (MARIN)
o. Research for Danube Navigation, by Via Donau in the Yearbook of the Austrian Association for Transport and Infrastructure.

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