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A green and economic future of inland waterway shipping

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Abstract

Presently, Central European waterways are utilized below their capacities while traffic volume on rail and road is increasing constantly. Especially road transport leads to high external costs caused by air pollution or congestion. Facing these problems, a new inland waterway ship called NEWS (FP7 Project, Development of a Next generation European inland Waterway Ship and logistics system) is being constructed.
The resource efficiency is going to be increased by up to 30% due to the adjustable LNG-gas-electric propulsion system. Additionally the fuel consumption can be decreased by 10% due to a new hull design. The main targets of this new development are to reduce greenhouse gas emissions and other pollutants and to shift transport volumes from the road to inland waterways to enable sustainable freight transport. This new development will be integrated in a ready-to-use inland waterway transport concept to fulfil the goals for competitive and resource efficient transport of the European Commission.

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Keywords: inland; waterway; transport; shipping; LNG; container transport; NEWS; multimodal transport; external costs; car-carrier

1. Introduction

Freight transport on European inland waterways is an environmentally friendly and cost-efficient way of transport. Nevertheless, the market share of IWT in Europe is only around 6,7% [1] and the economic situation of companies operating inland waterway transport (IWT) is, amongst others, characterized by an overaged fleet, eroding profit margins, a high dependency on fuel costs and delays caused by infrastructure bottlenecks.

The existing waterway system offers a large and untapped potential to manage increasing transport flows and to decrease congestion of road and railways. In total 29,172 km of European inland waterways have been earmarked by EU governments as waterways with international importance ("E-waterways"), whereby Russia, Ukraine and Belarus have no direct access to the rest of the European waterway network [2]. The most important European inland waterways are located in the North-South corridor, the Rhine corridor, the South-East corridor as well as in the East-West corridor (see Figure 1).

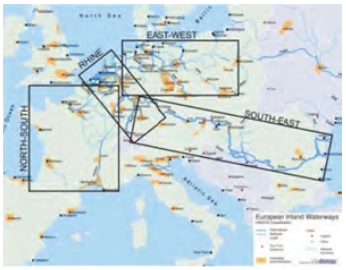

Fig. 1. Overview of European inland waterways [3]

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Promising chances to promote a modal shift can be identified in branches which are rarely exploited by inland waterway transport (IWT) - such as the transport of new passenger cars. The European automotive industry with an annual production of around 19 million passenger cars in 2013 contributes to the high transport volume in Europe on a large scale [4]. Passenger cars are assembled in more than hundred production plants [5], and many of them are located in one of the above-mentioned corridors. To increase the competitiveness of IWT new ways of utilizing the existing waterway-network have to be found.

Meeting these challenges the development of an innovative inland vessel has started in March 2013 in the course of the FP7-funded project "NEWS" standing for Development of a **N**ext generation **E**uropean inland **W**aterway **S**hip and logistic system. NEWS combines technical and logistical innovations to assist European cross-border challenges such as optimizing inland waterway transport and to integrate waterborne transport into the intermodal logistic chain.

Globally, the modal shift to IWT is supported by an increasing number of international projects which are often focusing on creating the frameworks necessary for the modal shift to IWT (especially in developing countries). The World Bank (World Bank Transport Anchor group – TWITR) initialized the working paper "Development of a more energy efficient inland waterway transport in Bangladesh" (2011) with the aim of reducing the modal share of road transport and creating the base for other project in developing countries [6]. In China the World Bank allowed a specific investment loan (2005) for the execution of the "Fifth Inland Waterways" project which aimed for the further development of the Han-river for IWT and at the same time for implementing sustainable energy (hydro-power) along the river [7]. India is already strongly committed to the development of IWT as the Inland Waterway Authority of India (IWAI) has been constituted in 1986. The IWAI developed and formulated a IWT policy with a view to accelerate IWT development and encourage private sector participation in IWT. Moreover, with financing of the World Bank projects such as "Capacity Augmentation of the National Waterway" or the project "IWT Sector Development Strategy and Market Development Study for Capacity Augmentation of National Waterway" (both started in 2014) are carried out [8].

Inside the European Union NEWS is among other projects which are either aiming for the development of innovative vessels and ships or for the collection and provision of necessary data to support the modal shift to inland waterways. In the following, some similar projects will be investigated to create a better understanding for the overall impact which can be achieved. The project "Innovative Danube Vessel" (finished 2013) was part of the "EU Strategy for the Danube Region" [9] with the goal of collecting and analyzing data related to operating ships on the Danube, the Danube fleet compositions and effected markets in order to give recommendations for the development of innovative Danube vessels. Regarding the impact of pollutant emissions of IWT the project called "Pollutant emissions reduction of IWT ships on the Danube Corridor" (part of: EU Strategy for the Danube Region; end date 2016) aims for the collection and analyzes of the effect of pollutant emissions along the Danube corridor and in the following for the development of an eco-friendly ship as well as the concept of a "green port". Considering the already existing vessels operating in IWT the project "Modernisation of Vessels for Inland Waterway Freight Transport" (part of: EU Strategy for the Danube Region; finished 2014) determined the framework conditions and the requirements for the retrofitting of existing inland ships. Closely related to the project NEWS (NEWS is also utilizing LNG-electric energy- and propulsion system) two projects are targeting the topic of LNG (liquefied natural gas) as a fuel for cargo in inland navigation (part of: EU Strategy for the Danube Region). The project "LNG Masterplan for Rhine-Main-Danube" (finished 2015) delivers the so called LNG Masterplan. This plan aims to create a platform for the cooperation of authorities and industry stakeholders with the purpose to facilitate the creation of a harmonized European regulatory framework for LNG as fuel. Related, the project "LNG Power Train for Danube Inland Navigation" (finished 2011) contributes to the implementation of usage of alternative fuels in Danube navigation. Investigating completely new ways of propulsion technology the project "WINTECC – Demonstration of an innovative wind propulsion technology for cargo vessels" (partly EU-funded; finished 2009) aimed for demonstrating the energy and greenhouse gas savings achievable by using a towing kit system for propulsion (5% -12% fuel savings depending on wind conditions). [10]

In the following chapter the Project NEWS is introduced by highlighting the technical aspects of the self-propelled vessel and, furthermore, the development of a car carrier based on the NEWS-concept is presented. Investigating the market potential of NEWS in the Automobile Industry (Europe) finally allows deduction about the reduction of external costs as well as environmental influences.

2. Self-propelled Vessel - NEWS

NEWS is being projected as a self-propelled vessel for the main usage on the Danubian waterway system, being capable of carrying three layers of containers stacked and four side-by-sides (see Figure 2). NEWS is able to operate on at least 80% of the European Inland Waterways.

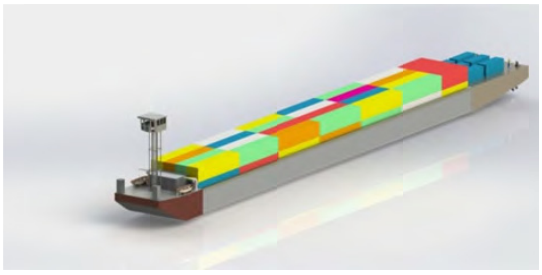

Fig. 2 Self-propelled vessel NEWS

In general, NEWS' most decisive technical and logistical features beyond the state-of-the-art are:

- Re-design of the vessel's hull (increase of transport efficiency)
- Adaptable draught allows crossing low bridges and reacting to altering water-levels due to a ballast tank (increase days of navigability)
- Adjustable LNG-electric energy- and propulsion system (increase resource efficiency - up to 30% - and decrease of harmful exhaust emissions)
- Adapted logistics-system for the respective demands of targeted markets
- Possibility of adapting the container vessel NEWS for multi-purpose use such as a river-sea going vessel or a car carrier

Regarding technical and logistical aspects to be considered whilst developing such a vessel, some framework conditions need to be mentioned: Hence, limitations of draught and air draught on the Danube as well as most of the European inland waterways have to be followed (e.g. 2.5 m). At the same time, a sufficient ballast water capacity and adequate side height to reduce the air draught when necessary have to be guaranteed to react flexible on changing water levels (see Figure 3).

Fig. 3 Adaptable draught of NEWS

Obviously, sufficient longitudinal strength as a structural design requirement has to be provided. Statistic calculations of the bending moments of bottom and side structure showed that all four values of corresponding stress are clearly below the allowable stress value of 16 kn/cm² for conventional structural steel.

Based on the concept of "NEWS", an easy to load/unload car-carrier will be developed, enabling up to two more decks to carry passenger cars and increasing its carrying capacity by 30 to 50 % (See Figure 4 and Figure 5).

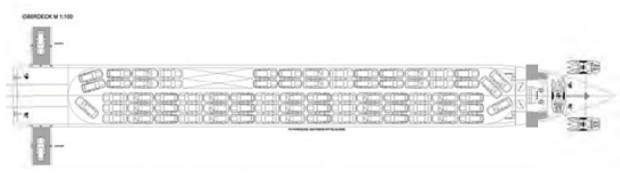

Fig. 4. Top view car-carrier

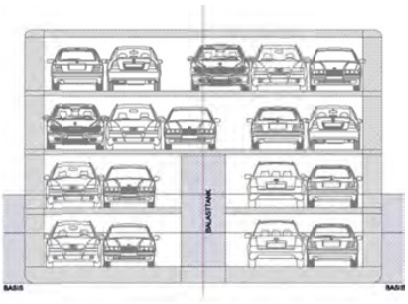

Fig. 5. Cross-sectional view car-carrier

Whereas conventional car-carriers operating on the Danube (e.g. "MS Heilbronn" and "MS Kelheim") are able to load 230 cars with a length of 4 meters, the car carrier NEWS will be able to carry approximately 360, leading to a significant increase of transport efficiency of 56%. The NEWS car-carrier shall be able to be operated within the above-mentioned waterway corridors in Europe and therefore helps to enlarge the European waterway system for efficient and ecological multimodal car transport. NEWS can be considered as one innovative transport mode for the distribution of passenger cars utilizing IWT in Europe especially when focusing on the operational costs for the transport.

3. IWT-Market Potential in Automotive Industry for the NEWS car-carrier (Europe)

Ten different countries, which are marked in green in Figure 6, are connected by navigable inland waterways within the Rhine and South-East corridors. In this catchment area, freight transports on inland waterways with class IV or higher are realizable.

Fig. 6. Potential countries for the distribution of passenger cars [own map]

Production plants for passenger cars are located in seven out of these ten countries. Vessels as car-carriers, such as NEWS, could be used for main haulage to deliver cars from

the production plants to the distribution centers within the target markets.

Table 1. Production plants in the catchment area [5]

Country	Number of Production Plants	Brands
Belgium	2	VW, Ford
Germany	24	BMW, Daimler, Ford, General Motors, VW
Austria	1	Magna
Slovakia	3	VW, PSA, Hyundai
Hungary	3	Suzuki, VW, Daimler
Serbia	1	Fiat
Romania	2	Renault, Ford

Analyzing the possible modal shift to IWT the locations of the production plants and as a result the distance to the waterway utilized has to be considered. Figure 7 shows the most relevant ports in the catchment area along the Rhine-Main-Danube as well as the 15 most relevant production plants.

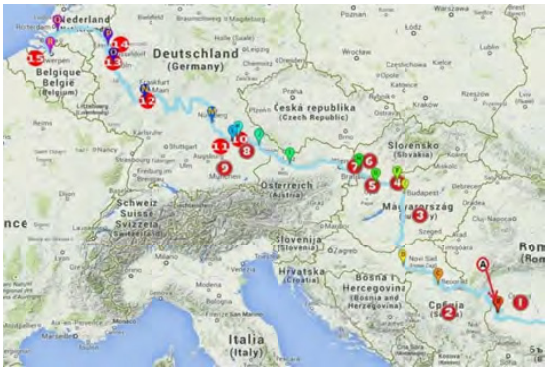

Fig. 7. Map visualization of the relevant assembly plants and ports (own figure by the help of Google Maps Engine)

In a next step the pre-haulage distance of the 15 most relevant production plants to the nearest port is extracted in order to highlight that the modal shift from IWT does not require long inland transports to the ports (only 2 of the 15 production plants with more than 100km to the nearest port). This holistic view of the logistic chain builds the base for further analyzes of the potential of a modal shift to inland waterways.

Table 2. Relevant plants in the CA and distance to nearest port

OEM	**City (Country)**	**Pre-haulage [km]**
Ford of Europe	Craiova (Romania)	92
Fiat S.p.A.	Kragujevac (Serbia)	145
Daimler AG	Kecskemet (Hungary)	95
Suzuki	Esztergom (Hungary)	8
Volkswagen AG	Gyor (Hungary)	15
PSA Peugeot Citroën	Trvana (Slovakia)	51
Volkswagen AG	Bratislava (Slovakia)	23
BMW Group	Dingolfing (Germany)	47
BMW Group	Munich (Germany)	103
BMW Group	Regensburg (Germany)	8
Volkswagen AG	Ingolstadt (Germany)	56
General Motors Europe	Rüsselheim (Germany)	15
Ford of Europe	Cologne (Germany)	0
General Motors Europe	Bochum (Germany)	46
Volvo Car Corporation (Geely)	Gent (Belgium)	56

An analysis of the origin of the assembled cars and the number of car registrations in each country in 2013 showed that more than two million cars have been assembled and also sold in the specified catchment area (see Figure 8). The potential including imports and exports from and to outside the catchment area is even higher.

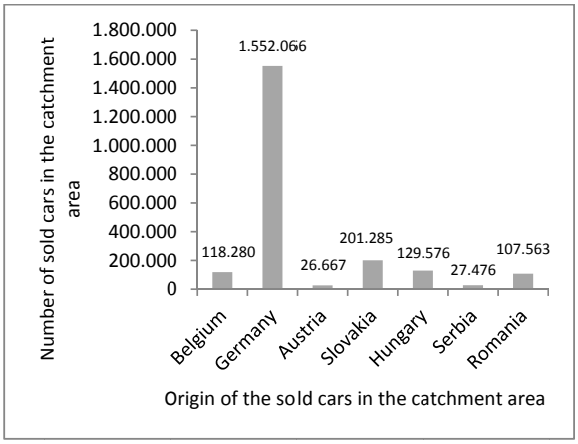

Fig. 8. Origin of the sold cars in the catchment area [own figure; several data]

To answer the question how many cars could reasonably be distributed on inland waterways in the catchment area a comparison between the costs for direct transport and multimodal transport would be necessary.

4. Reduction of external costs utilizing NEWS in Inland Water Transport

Congestion, air pollution, climate change, accidents, noise and infrastructure wear and tear are examples of effects related to the transport activities that generate costs not fully borne by the transport users. Without policy intervention these costs, called external costs, are not taken into account for the selection of the appropriate freight transport mode.

The White Paper 2011 (first edition dated in 2001), “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system," has been issued by the European Commission [11]. It is constituted by 40 initiatives to be actuated until 2020 in the European Union and one of these is called “Smart pricing and taxation." This initiative is divided into two phases:

- the first (until 2016) expects to phase in a mandatory infrastructure charge for HDVs (Heavy-Duty-Vehicles) and to proceed with the internalisation of external costs for all modes of transport

- the second (from 2016 until 2020) especially targets on implementing a full and mandatory internalisation of external costs (including noise, local pollution and congestion on top of the mandatory recovery of wear and tear costs) for road and rail transport. It will examine a mandatory application of internalisation charges on all European inland waterways

For the purposes of this paper, the Marco Polo Calculator 2013 has been utilized to calculate the external costs of freight transport. The European Union's Marco Polo Program aims for shifting from freight transport on the road to other more environmentally friendly transport modes. This program runs yearly calls for proposals, and one of the parameters determining financial support for the proposals received is the level of the environmental and social benefits expected. The calculator covers road, rail, inland waterway and short sea shipping providing external costs for environmental impacts (air quality, noise, climate change) and socio-economic impacts (accidents and congestion) per ton-kilometer [12]. Table 3 shows the external cost values used in this paper.

Table 3. External costs monetary values [6]

Externality [€/t·km]	**Road** (motorways)	**IWT (Freight** Capacity: ›3000 [t]; Fuel: LNG)
Air pollution	0.00858	0.0021
Climate change	0.00392	0.0012
Noise	0.00193	X
Accidents	0.00064	X
Congestion	0.00343	X
TOTAL	0.0185	0.0033

It has been chosen to carry out a practice-related comparison regarding external costs between the main haulage by truck and the main haulage by ship (using the NEWS vessel). For this use-case a transport route starting from the Port of Bratislava to the Port of Rotterdam has been chosen (see Figure 9). Altogether, according to our calculation, more than 26 thousand cars (equivalent to more than 23 thousand tons - see Table 4) have been transported from VW Bratislava to the target markets Netherlands and Belgium in the year 2013.

Fig. 9. Selected route for the case study [13]

Table 4. Weight of the passenger cars transported from Bratislava to Rotterdam [own table]

Model	**Curb (or kerb)** Weight [t]	**TOTAL Weight in 2013** Belgium	Netherlands
Volkswagen UP!	0.859	1,799	13,899
Skoda Citigo	0.860	589	2,601
Seat Mii	0.858	325	3,121
Volkswagen Touraeg	2.149	389	208
Audi Q7	2.272	509	202
	TOTAL	3,611	20,032

Table 5. External costs comparison for Bratislava to Rotterdam [own table]

Total Weight of passenger cars transported in 2013 [t]	**Road** [km]	**River** [km]	
23,643	1,282	1,569	
Road Transport Total External Costs [€]	**IWT Total External Costs** [€]	**Road Transport Climate Change Costs** [€]	**IWT Climate Change Costs [€]**
560,657	122,427	118,799	36,467
% Reduction =	78%	% Reduction =	69%

Table 4 shows the results of the external costs calculation considering the total external costs and the climate change costs. Using NEWS, it can be shown that a total external costs reduction of around 78% is reached as well as 69% when considering only the climate change costs.

As the case has been carried out taking the numbers from 2013 a deeper investigation of the future developments is required to relate the case study to the EU roadmap until 2020. The prognostic development of the car production in Europe states that the overall production of cars will increase from 19 million cars in 2013 up to 23.2 million cars in 2020 [4] which equals 22% increase. The parameters from the case study have to be taken ceteris paribus (monetary values for external costs - Table 3 - only change due to changes in technology). This prognostic view would result in the total external costs for road transport increasing proportionately in 2020 as well as the reduction of external costs using IWT (all by 22%). Increasing reductions of IWT compared to road transport will depend on the technological developments of both the road transport as well as the IWT as these developments would change the monetary values of the external costs.

5. Conclusion

Shifting freight transport from road to other modes such as railway or especially inland waterway - and thus encourage intermodal transport – is not only a political aim followed in Europe. (For example: EU Strategy for the Danube Region is to increase the cargo transport on the Danube by 20% by 2020 compared to 2010). It is also followed in developing countries such as China, India and Brazil with comparably high growing-rates of IWT [14].

Therefore, the project NEWS works on developing and validating the innovative container inland vessel NEWS for the Danubian waterway system. The LNG-electric power management is highly innovative and the power splitting concept promises a significant reduction of ecological impact and supports the sustainability of IWT.

A rough calculation of external costs on selected transport routes revealed that using NEWS (IWT for main haulage) results in considerably high reductions regarding the climate change costs as well as the total external costs.
NEWS supports increasing transport efficiency and allows an ecological and economical efficient container transport on the Danube and helps to make inland waterway transport more attractive for the intermodal transport.

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