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An Inland Waterway Option for Sustainable Freight Transport in Southeastern Europe

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ABSTRACT

The Axios-Morava waterway project has been dreamt about by the people of the Balkans for at least five generations and today is closer to becoming reality than ever before. The main drivers to revisit this subject today are associated with the availability of the necessary technical and management know-how, the international investment interest, as well as the demand for environmentally sustainable growth to which transport in general and inland navigation in particular will play a major role.

It was demonstrated that the potential of the Axios-Morava navigable link between the eastern Mediterranean Sea (via the Aegean) and River Danube for the transport of freight offers an energy and carbon favourable alternative to road, whilst it competes closely with rail. With regard to air quality, the waterway service was found to be better than the rail but significantly inferior to the road mainly due to the stricter emission standards applicable to trucks. Finally, it was demonstrated that it is necessary to build on the ongoing international interest in this project, as being the driver for implementing all the necessary infrastructural and operational changes which will make the proposed waterway service commercially and environmentally sustainable.

1. Introduction

During the course of the last three decades, international trade has increased at a rate much faster than the growth in global GDP and in relation to 1975 the increase of the former has been nearly double to that of the latter (UNCTAD, 2012). During the last decade this trend was intensified through the rapid economic growth of east Asia and the establishment of significant seaborne freight flows between the far-east (mainly China) and the west (USA and Europe) through the transpacific and east-west (via the Mediterranean) routes (Figure 1).

For Europe and particularly for the EU, this eastward shift in trade continues to be predominately served through the northern range ports and their logistical chains utilizing and building on the investments made in support of the previously dominant Europe-USA trade. Although there are signs of correction in this north-south imbalance of extra-European trade flows, mainly evident through the increased port throughput in the western Mediterranean basin, northern gateways have in general retained their ability to counter the proximity advantage of Mediterranean ports for the Asia trade (Gouvernal et al., 2012).

However, the need to strengthen the role of the European ports of the Mediterranean in international trade is now becoming urgent for ensuring sustainable growth within the European continent as a whole and that of EU in particular (Costa, 2013). This urgency is intensified with regard to the eastern Mediterranean basin, as the increased trade demand associated with the EU-enlargement into eastern and southeastern Europe and the recent economic growth observed in all the countries of this region has to be met.

As the seaborne trade between the Far-East and Europe via the East-Med is rapidly expanding, the new manufacturing and consuming centers established throughout the eastern region of central Europe seek the support of nearby and easily accessible trade gateways. The compounded influence of the eastward shift of both the global and European economic centres of gravity highlights the importance of the east-Med European ports

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in EUs strive to develop a competitive and resource efficient freight transport system.

In this respect, the latest White Paper - *"Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system"* (EC, 2011), sets a range of specific targets including modal shifts towards sustainable and energy efficient modes of transport, as well as reduction goals in GHG, pollutants and oil consumption. Despite all efforts, the growth of the non-road modes of freight transport remains a strong challenge for Europe, as during 2001-2011 road-borne freight strengthened its share from 75% to 76% of the total inland intra-EU transport work (ton-km), whilst railways were reduced to 18% (from 19%) and waterways maintained their portion of 6%.[3]

The White Paper acknowledges the fact that so far rising volumes of freight transport have outweighed efficiency gains in transport and new vehicle and fuel technologies alone will not be sufficient to meet the challenge of sustainable EU transport by 2030 and 2050. Therefore, *"specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs will be also necessary"*. Amongst the ten key benchmarks of the White Paper for the achievement of a competitive and resource-efficient transport system are included:

- *"A 30% shift of road freight over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors"* and
- *"A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high-quality and capacity network by 2050 and a corresponding set of information services"*.

Both benchmarks are relevant to *"the optimisation of the performance of multimodal logistic chains, including the greater use of more energy-efficient modes"* which constitutes one of the three pillars of the White Paper strategy on transport. Furthermore, it is also stated that *"On the coasts, more and efficient entry points into European markets are needed, avoiding unnecessary traffic crossing Europe. Seaports have a major role as logistics centres and require efficient hinterland connections. Their development is vital to handle increased volumes of freight both by short sea shipping within the EU and with the rest of the world"*. And with specific significance for this paper, the previous statement closes by the sentence: *Inland waterways, where unused potential exists, have to play an increasing role in particular in moving goods to the hinterland and in linking the European seas*. Towards meeting this objective, the knowledge and experience gained through the NAIADES I (2006-2013) and NAIADES II (2014-2020) programmes for the *Navigation and Inland Waterway Action and Development in Europe*, as well as the implementation of their supporting programmes PLATINA I and II, will play a major role [4].

The role of inland navigation in a sustainable transport system has been recently studied by Rohacs and Simongati (2010), whilst the significance of River Danube as a vital transport artery for the EU and the European continent has been presented in the work by Mihic et al. (2011) and by Radmilovic and Maras (2011). Furthermore, the environmental impact of inland navigation in the context of the air pollution produced by the riverboats has been addressed by Den Boer (2011), whilst the work by Radojcic (2009) was conducted with reference to Danube and that by Ljevaja (2011) and Radonjic (2011) for Serbia.

Amongst the people of the Balkans, the concept of the Axios-Morava navigation route connecting the eastern Mediterranean (via the Aegean Sea) with River Danube dates back to at least five generations, but the first comprehensive approach into its feasibility was presented by Jovanovski (1993) and has lately resurfaced as a project proposition mainly due to the expressed international interest in the project amidst a mounting pressure to develop sustainable transport corridors in Europe (Corres, 2014; Duncic and Lukic, 2013; Radakovic, 2012). The ongoing political and economic reform within the Balkans makes the region the ideal playing field for each of the great powers i.e. USA (via NATO and EU), Russia (via Serbia) and China (via Serbia), in their effort to establish their presence and exercise their influence in the future affairs of the wider region.

This paper makes a unique contribution to existing literature, because it examines the Axios-Morava waterway within the context of the current White Paper strategy on EU transport. More specifically, the comparative analysis with the competing modes of road and rail freight in terms of fuel use and atmospheric impacts highlights the challenges associated with the proposed modal shift with regard to energy efficiency and environmental (atmospheric) quality.

2. Description of the Waterway Link

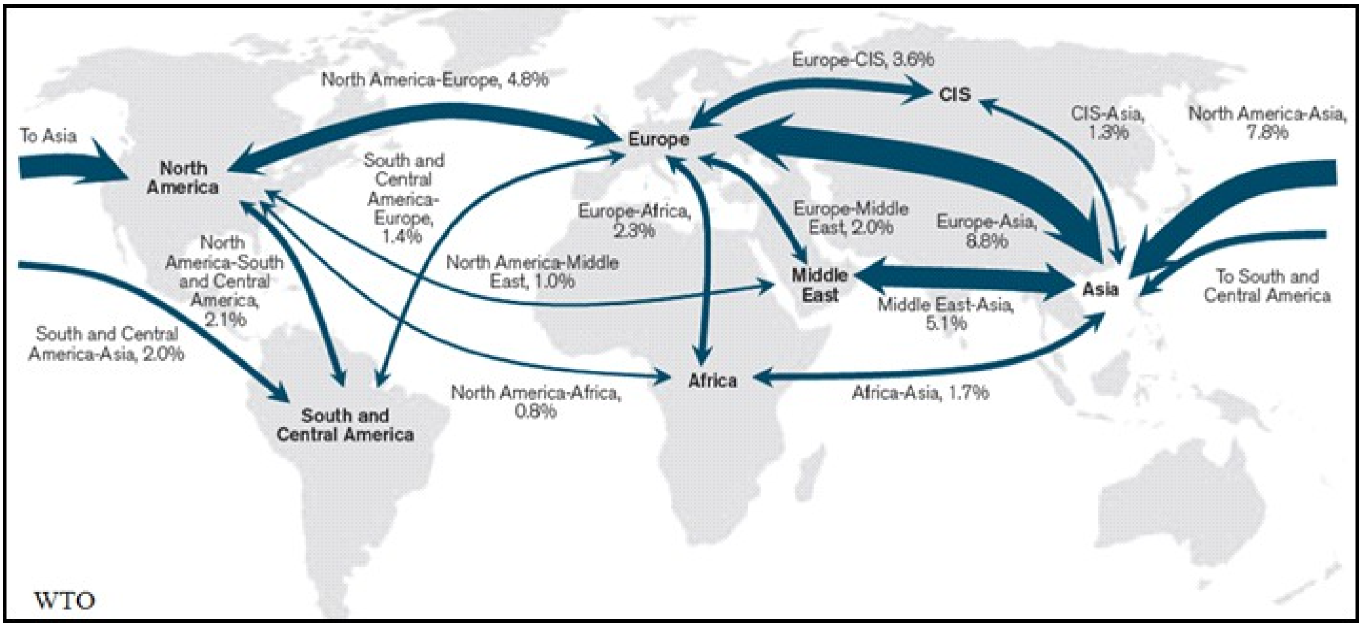
Danube with a length of around 3000 km is the longest river in the EU and through its connection with the Rhine-Main (500 km) forms a fully navigable link between the North Sea (Rotterdam) and the Black Sea (Constanta), thus being an integral part of the Trans European Transport Network (TEN-T). Danube passes through ten riparian countries (seven EU member states) and its basin extends to nine more, contributing to the socio-economic growth of central, eastern and south-eastern region of the European continent.

The proposed waterway link essentially utilizes the route offered by the Axios (or Vardar) River at the south and that of Morava River over the north section (Figure 2). Axios is the longest river that runs through Greece and FYROM, having a length of 275 km, with a width presently ranging from 50 to 600 m and a depth which can reach up to 4 m. It extends northbound into FYROM territory under the name Vardar and

[3] Energy, transport and environment indicators - 2013. http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/publication?p_product_code=KS-DK-13-001

[4] http://www.naiades.info/

Figure 1: Distribution of international trade flows (2011).



Source: Authors

Figure 2: Axios-Morava inland waterway.

Source: Authors

joins the Morava River further north. The Morava runs over 345 km through Serbian land and joins the Danube at 50 km east of Belgrade. The overall length of the waterway link between the Aegean Sea and River Danube is equal to 650 km, thus offering a 1200 km shorter route between the eastern Mediterranean and central Europe (via the Black Sea).

However, making the Axios-Morava waterway navigable and ready for service will require extensive construction work, which will involve the building of canals (a short main canal and 4-5 lateral), wharfs, numerous locks and dams, as well as the opening of new roads and other supporting facilities. To this effect, the accumulated knowledge and experience in the building and operation (incl. maintenance) of navigable waterways is adequate for such undertaking. In terms of added value, the construction and operation of the waterway link will bring socio-economic growth in the region, whilst the riverborne trade will boost the productivity of the agricultural sector which is dominant in this peripheral area of Europe.

3. International Interest

Although the discussion for the navigability of Morava dates back to the 1840s, the development of the entire Axios-Morava link into a navigable waterway was of a scale and character which was bound to require international intervention. In 1907, the American government established in New Jersey the American engineering commission for the observation of the Morava-Vardar waterway. The Balkan wars of 1912-13 and the regional instabilities of the interwar period put the project aside. After the end of WWII and up to the beginning of the 80s, the political orientation of former Yugoslavia was not favouring the co-operation with the West and most importantly Greece as a riparian country, whilst the emergence of ethnic tensions between Serbia and the ex-Yugoslavian republics during the 80s and their eventual engagement in war during the 90s (terminated with the NATO bombing of Serbia in 1999) inevitably placed the region under other priorities.

The big change came recently through the attraction of the Chinese interest in investments throughout the Balkans. After visiting more than thirty locations along the route, during a period of three months, the Chinese have concluded that the project is technically feasible and funding will follow the example of COSCO's concession in the port of Piraeus. Combining China's interest in this project, it is important to note that with major Chinese investments in the ports of Piraeus and Thessaloniki, and with similar projects in the infrastructure sector in the countries of southern and southeastern Europe, *"China creates an alternative route for the entry of products in Europe, which is the largest market and which, unlike the ports* *of northern Europe, it would be for 99 years under its influence and management"*, significantly boosting its geopolitical position Apart from Greece, FYROM and Serbia which are directly involved, the project is also attracting directly or indirectly the attention of Russia, EU and the USA. In this context, there is already Russian interest in the privatization plan of the Hellenic Railways and the Port of Thessaloniki, whilst the EU is bound to exercise its influence through:

- Serbia's accession negotiations with the EU started on January 1^{st} 2014.
- The policy for river transportation (NAIADES II) which integrates it into the European Transport Networks (TEN-T) with a substantial budget for infrastructure projects.
- The socio-economic interest in the developmental character of the project.

Last, but not least, although the project does not clearly relate to USA interests in the transport sector, it is otherwise significant within the framework of geopolitical influence. A possible long term presence of Chinese and/or Russian interests in the region could clash with other USA priorities especially after the recent developments in Ukraine.

4. Performance of the Waterway Link

The performance of a waterway link is mainly related to the riverboats which use it and specifically to their design parameters which are dictated by the navigational constraints imposed upon them. Riverboat water and air draft, length and beam are tailored to the waterway natural and man-made characteristics. For example, navigability through the entire stretch of River Danube allows a maximum loaded draft of around 2.0 m to account for adequate clearance at swallow waters. In general, beam and length are restricted by the size of locks with length being also limited by waterway bends and air draft by the height of bridges.

A critical performance parameter in waterway freight services is that of transit time, as it is widely acknowledged that it is the slowest mode of motorized transport. This stems basically from the fact that cargo riverboats have a full-body hull which inevitably restricts their speed in favour of increased cargo carrying capacity under the waterline. Furthermore, waterway authorities usually impose speed limits to avoid damage to river banks and wharfs produced by the hull wake which can be profound in swallow waters especially near the critical (hull) speed regime. During sailing in swallow waters, squat effects must also be controlled through the reduction of speed. Away from these constraints, low draft vessels can reach service speeds of 20 km/h, but transit times are also prolonged due to delays at the locks (waiting at entry and lock transit) and in many cases because only daytime navigation is allowed.

A concise presentation of the basic designs (self-propelled, barges etc) of freight riverboats engaged in Europe is given in the work by Radmilovic and Maras (2011), whilst detailed descriptions of the various designs involved in the European

Figure 3: Axios-Morava inland waterway.

Source: Authors

waterway network in general and for River Danube in particular can be obtained through the reporting of the SPIN-T programme available at: `http://spin-tn.factline.com/`.

The types of riverboats which are currently active in Danube range from dry bulk carriers and tankers to general cargo (incl. containers) carriers and Ro-Ro. Self-propelled riverboats vary from 38-40 m long having a payload capacity of about 300 tons at 2.5 m draft to 110 m long with on average 1900 tons payload at the same draft. In recent times even considerably larger vessels have become usual on the Rhine River having a length of up to 135 m, a beam of up to 17 m and a payload of about 3500 tons at only 2.5 m draft. Barges range between 70.0-76.5 m in length, a beam between 9.5-11.4 m and a cargo carrying capacity which is mainly determined by the available depth of the waterway. Indicative draft for a given payload of a typical Danube barge (77x11x2.8 m) is: 1.0 m for 300-400 tons, 1.5 m for 700-800 tons, 2.0 m for 1100-1200 tons, 2.5 m for 1500-1600 tons, 2.8 m for 1800 tons and 4.0 m for 4000 tons. Barge convoys usually consist of 2 to 6 barges which carried in various combinations in tandem and/or in parallel by a push boat (or very rarely by a pull/tug boat) of appropriate power. Finally, a self-propelled river boat may also carry 1 or 2 barges abreast.

Table 1: JRB's riverboat fleet.

Riverboat Type		Number	Average Payload Capacity (tons)	Average Propulsion Power (kW)
Barges	Dry Cargo	62	1732	-
	Liquid	58	1386	-
Self Propelled	Dry Cargo	1	1892	1276
	Liquid	1	1246	551
Pushboats		14	-	1199
Tugboats		2	-	885

Source: authors

Indicative data with regard to the riverboat characteristics which would be more suitable for the Axios-Morava waterway link can be obtained through reference to the fleet of the largest river shipping company in Serbia, "Yugoslav River Shipping" / "Jugoslovensko Recno Brodarstvo (JRB)"[5] . The main particulars of the JRB fleet are synoptically shown in Table 1 and their dry cargo self-propelled riverboat in Figure 3.

5. Energy Efficiency and Atmospheric Impact

At a time of increased commercial competition and fuel prices, the energy efficiency offered by transport services is very important as fuel expenditure constitutes a major part of their overall cost function. However, apart from the internal (private) costs, transport companies are faced with the challenge of reducing their negative externalities mainly in order to alleviate the social costs amidst the emerging wave of their cost internalization, but also in an effort to improve their commercial image. The most important transport-related exhaust emissions have atmospheric impacts at global (CO_2) and regional/local (SO_2, PM and NOX) level causing significant damage to the natural and built environment, and most importantly to human health (Table 2). However, the fact that energy savings reduce emissions either directly (for CO_2) or indirectly (for the other pollutants) presents transport companies with a powerful incentive to improve their energy efficiency record in order to cut down on fuel costs and improve their environmental performance too.

Table 2: Impact of exhaust emissions

Emission	Impact
CO_2	Global warming - Climate change
SO_2	Acidification, eco-toxicity, human toxicity
PM	Human toxicity, summer smog
NO_x	Acidification, eutrophication, eco and human toxicity, summer smog

Source: Authors

The comparative analysis on energy efficiency and atmospheric impact between the three competing transport services (waterway, road and rail) was partly based on the EcoTransIT[6] tool, which was considered most suitable for application on specific routes of freight transport. This tool builds on the experience of previous research programmes (e.g. TRENOVE), uses internationally accepted methodologies and databases for transport-related energy and emission calculations and is regularly updated on the emission regulations for the various modes of transport. Furthermore, it is GIS-based for finding the "fastest"[7] route and offers flexibility in terms of specifying vehicle operational and design parameters. However, as this tool relies on real-life data with regard to O/D route points, it was not possible to utilise it for the Axios-Morava waterway link and it was only applied for the road and rail connections with reference to the adjacent Thessaloniki-Belgrade route. Finally, in an effort to achieve the nearest level-playing framework for comparing the energy and emission performance of the three competing transport services, the vehicles considered were of the highest payload capacity[8] which was fully utilised with heavy bulk cargo, whilst it was assumed that the latest emission standards apply for the vehicle engines employed in each mode of transport.

The energy use and the exhaust emissions produced by the Axios-Morava waterway service were estimated through the application of an activity-based methodology which accounts for the riverboat design and its operational profile as it transits the waterway. It was assumed that a twin-screw diesel-powered riverboat (similar to that of Fig. 3) at a fully loaded condition of 2000 tons (i.e. at 2.7 draft) will require about 50% of its MCR of 1300 kW to develop a speed of 10 km/h at a relatively swallow depth (¡ 4.0 m) typical of the Axios-Morava waterway. At this sailing speed, the passage through the entire Axios-Morava waterway will take a total transit time of 180 hours (or 7.5 days), as analyzed in Table 3.

Table 3: Transit times for Axios-Morava waterway service.

Sailing distance (km)		650
Sailing speed (km/h)		10
Sailing speed (km/h)		12
Number of overnight stops		5
No. of Locks (5-stage)		11
Lock time	Waiting at lock entrance (h)	2
	Lock transit (h)	3
Total sailing time (h)		65
Total stoppage time (h)		60
Total lock time (h)		55
Total Waterway Transit Time(h)		**180**

Source: Authors

The operational and exhaust emission parameters of the main engine necessary for estimating the energy and emission performance of the riverboat during the waterway service are shown in Table 4.

With regard to NO_x and PM emission coefficients of the riverboat, the standards of latest European Directive 2004/26/EC for non-road engines were applied, as they cover all new engines involved in inland navigation from 01/07/2007. Furthermore, the SO_2 emission coefficient was estimated using the LR (1995) expression for medium speed diesel (MSD) engine operation on maximum sulphur content of 10 ppm, as applied to inland waterway transport from January 1^{st}, 2011 (Directive 2009/30/EC). The CO_2 emission coefficient and the specific fuel consumption (s.f.c.) of the engine, as well as the fuel effective heating value (EHV) were based on the work by Cooper

[5] `www.jrb.rs/index.php/en/transportation`

[6] Ecological Transport Information Tool for Worldwide Transports, `http://www.ecotransit.org`

[7] Based on ease of traffic flow, motorways are less resistant than national roads.

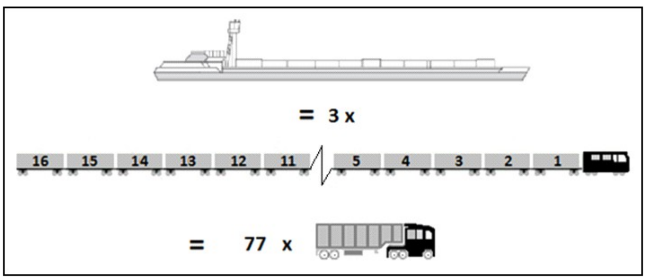
[8] Usually observed in the region.

Table 4: Riverboat propulsion engine emission coefficients and fuel consumption.

Emission Coefficient (g/kWh)	CO_2	645
	SO_2	4.2 x 10-3
	PM	0.2
	NO_x	6.0
s.f.c. (g/kWh)		203
MDO/MGO EHV (MJ/kg)		42.4

Source: Authors

Figure 4: Number of vehicles for payload capacity equivalence of 2000 tons.



Source: Authors

and Gustafsson (2004) for marine MSD engines working on MDO/MGO.

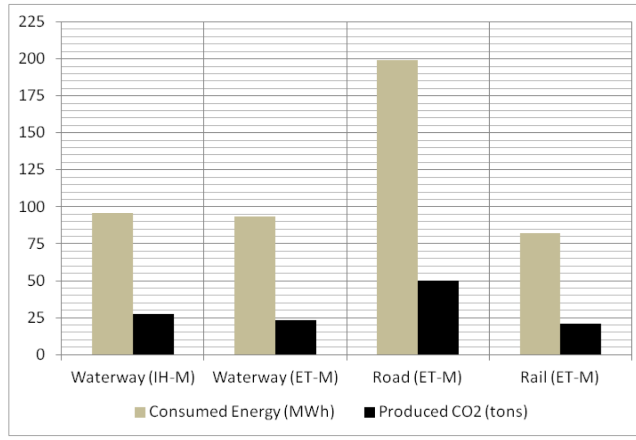
For testing the reliability of the aforementioned activity-based methodology and data for the modeling of the Axios-Morava waterway service, it was considered appropriate to apply the EcoTransIT tool over a sizable segment of River Danube linking real-life points with a riverboat of identical emission performance standards (i.e. 2004/26/EC compliant) and payload carrying parameters, and subsequently scale the EcoTransIT output according to the sailing distances of the two connections. The link of ”Vienna Danubepier Hov” and ”Budapest” covering a sailing distance of 277 km was selected to provide the test for the 650 km long Axios-Morava service.

The road service between Thessaloniki and Belgrade was assumed to employ diesel-trucks of 40 tons gross weight (26 tons payload capacity), whilst the railway used diesel-pulled wagons each of 84 tons gross weight (61 tons payload capacity) in a train formation of nearly 1500 tons gross weight, both being typical of the heaviest types operating in this region (Figure 4). As already mentioned, similar to the load factor of the riverboat, both land-based vehicles were set to operate at their full payload capacity. According to the EcoTransIT tool, the ”fastest” rail and road distance between Thessaloniki and Belgrade was found to be equal to 664 and 677 km, respectively.

6. Results and Discussion

The energy consumed and the CO_2 produced during the single-leg (one-way) movement of 2000 tons of freight by the

Figure 5: Energy consumption and CO_2 emission per transport service.



Source: Authors

three alternative modes of transport is shown in Figure 5.

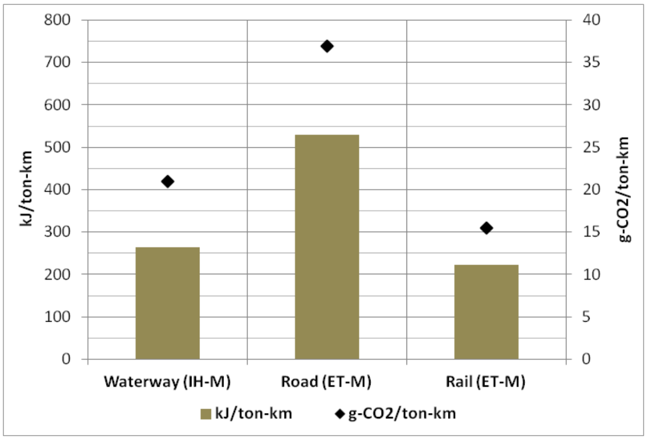
Firstly, it is observed that the results of the in-house modelling (IH-M) of the waterway service compare very well with those of EcoTranIT (ET-M), which provides a clear indication for the reliability of the current analysis.

Overall the waterway service was found to be significantly superior to that of the road and slightly inferior to rail. More specifically, based on the in-house modeling results, the energy consumed by the road service was more than double to that of the waterway, whereas the latter was 16.3% more energy thirsty than the rail service. The comparison is less favourable for the inland navigation with regard to CO_2 emissions, as its superiority to the road service is reduced to 83.2% and its inferiority to rail is increased to 32.5%. Although the diesel engine technologies and the fuels involved in the three types of vehicles can be commonly classified into the MSD/HSD engine and distillate fuel categories, there enough differences in terms of the exact engine and fuel specifications which can modify the energy-carbon relationship of each vehicle. In this context, the waterway service emits the most CO2 per unit of consumed energy, i.e. 290 kg-CO_2/MWh compared to the 250 kg-CO_2/MWh of the road and rail.

The energy and carbon efficiencies of the three services are shown in Figure 6, where the rail and waterway services are again superior in comparison to road. It is important to note that although this carbon efficiency ranking is consistent with that of other studies, the associated values are lower than those reported by McKinnon and Piecyk (2011) for inland navigation, heavy trucks (max. payload of 26 tons), diesel-rail at an average of 31, 62 and 22 g-CO_2/ton-km, respectively. This difference is mainly attributed to the vehicles' capacity utilisation which in the current analysis was assumed to be 100% for aiding the comparison across all transport modes, whilst in reality the load factors range between 55-65% depending on transport mode, cargo type and most importantly on the prevailing market conditions.

Taking into account that the current MDO/MGO price in the

Figure 6: Energy and carbon efficiency per transport service.



Source: Authors

region averages 900 \$/ton[9] , whilst the auto-diesel price stands at around 2150 \$/ton[10] , the fuel cost advantage of the waterway service over the road is substantial. More specifically, it was found that the riverboat burns 8.6 tons of fuel which gives an expenditure of around \$ 8000 or equal to 4 \$/ton of transported cargo and the trucks use around 17 tons of fuel for a cost of \$ 36,400 or 18.2 \$/ton.

In an attempt to distinguish between the produced CO_2 emissions which have a global impact and those which are important with regard to local and regional air quality (i.e. SO_2, PM and NO_x), the latter are presented separately in Table 5. The waterway service produces the lowest SO_2 emissions, although they do not offer a sizable advantage in comparison to the road and rail alternative. With regard to PM and NO_x emissions, the road service is by far the best option, whilst the waterway has a better performance in comparison to the rail service.

Table 5: Comparison of produced air pollutants per transport service.

Emission Type	Waterway (IH-M)	Road (ET-M)	Rail (ET-M)
SO_2 (kg)	0.2	0.3	0.3
PM (kg)	8.7	1.5	9.2
NO_x (kg)	253.5	123.1	334.5

Source: Authors

However, in real life, the gap between the emission performance of riverboats and the land-based vehicles is bound to increase further as a result of the enforcement of the EURO-VI for truck engines from 01/01/2013 (calling for NO_x and PM limits of 0.4 and 0.01 g/kWh, respectively) and the ongoing expansion of the railway electrification in Europe. As the introduction of emission standards discriminates between existing and new engines, the emission profile of the existing waterway fleet in Europe lags behind the post-2006 standards of Directive 2004/26/EC, because the rate of replacement of riverboats is characteristically slow in comparison to the observed renewal of truck and rail stock. There are numerous pre-1974 riverboats having NO_x and PM emission coefficients which are nearly double the currently permissible standards.

The improvement of the air quality performance of inland navigation is very important, because the air pollutant receptors are closer and hence more vulnerable to damage than those exposed to the coastal and ocean-going ship operations. Of course, similar to the case of short sea shipping, reducing the exhaust emissions of riverboats requires the use of "cleaner" fuels and/or the introduction of exhaust treatment technologies (e.g. scrubbers). The use of natural gas as a fuel for inland navigation will make riverboats environmentally superior to the other land-based transport modes and by virtue of their low energy requirements in comparison to their sea-going counterparts the ability to utilize CNG technology alleviates the problems associated with LNG bunkering particularly in the region under consideration.

However, the additional investments required to improve the emission performance of inland navigation are bound to increase the cost of the waterway services and make them commercially disfavoured in comparison to the other competing modes of transport. In an effort to avert the reverse modal-shift for inland navigation, it is necessary to realize that the attainment of sustainable transport in Europe requires an approach which will engage all stakeholders in sharing the risks and opportunities, and amongst them governments have a "governing" role to play in providing the correct policies (incl. appropriate incentives) to meet this challenge.

7. Conclusions

Inland waterways can make a significant contribution towards achieving transport sustainability in Europe and the EU in particular, and within the economically growing region of southeastern Europe their unused potential needs to be fully explored.

It has been shown that the Axios-Morava waterway through its connection with River Danube can offer a freight link between eastern Mediterranean and central Europe which with regard to energy and carbon efficiency is superior to the road alternative and slightly inferior to rail. However, its air quality performance needs to be significantly improved in order to match that of the road and maintain its superiority against the rail.

European transport policies must focus on providing the necessary incentives and mechanisms in order to support the infrastructural and operational investments which will promote the expansion of waterway utilization in a sustainable manner.

References

Cooper D, Gustafsson T. Methodology for Calculating Emissions from Ships: 1 Update on Emission Factors. Prepared for the Swedish Environmental Protection Agency by IVL Swedish Environmental Research Institute, February, 2004.

[9] `www.bunkerworld.com/prices/`
[10] `www.energy.eu/fuelprices/`

Corres A. From the Aegean Sea to the European rivers: The Axios-Morava-Danube link. Presented at the Hellenic Institute of Marine Technology, January 2014, Piraeus.

Costa P. Global trade flows: a key component of the Union's sustainability equation. Presented at "Connecting Europe: On the move to the new Ten-T", Ten-T Days 2013, October 2013, Tallinn.

Den Boer E. Instruments to reduce pollutant emissions of the existing inland vessel fleet. Presented at the International Workshop on "Emissions from the Legacy Fleet", November 2011, Delft.

Duncic D, Lukic J. The Project to Construct the Danube-Morava-Vardar-Aegean Canal. Presented at the 24^{th} Conference "Danube - River of Cooperation", September 2011, Belgrade.

EC. White Paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system. COM (2011) 144 final, 2011. Brussels.

Gouvernal E, Rodrigue J-P, Slack B. The divergence of regionalization: The challenges of the Mediterranean ports of Europe, Proceedings of the IAME 2012 Conference, September 2012, Taipei.

Ljevaja D. Impact of emission of marine diesel engines to air pollution on the example of the Yugoslav river shipping. International Journal for Traffic and Transport Engineering 2011; 1(3): 149-157.

LR. Marine Exhaust Emissions Research Programme, Lloyds Register Engineering Services, 1995, London.

McKinnon, A., Piecyk, M. Measuring and Managing CO2 Emissions of European Chemical Transport. Final report prepared by Logistics Research Centre, Heriot-Watt University, for Cefic - European Chemical Industry Council, 2011, Edinburgh.

Mihic S, Golusin M, Mihajlovic M. Policy and promotion of sustainable inland waterway transport in Europe - Danube River. Renewable and Sustainable Energy Reviews 2011; 15: 1801-1809.

Rohacs J, Simongati G. 2010. The role of inland waterway navigation in a sustainable transport system, *Transport* 22(3): 148-153.

Radakovic M. The Danube-Morava-Vardar-Aegean Sea Waterway, in Chapter III - Economic and Environmental Co-operation in the Danube Basin, Danube Strategy -Strategic Significance for Serbia, Eds. Nevenka Jeftic Sarcevic and Edita Stojic Karanovic, pp. 176-184, 2012.

Radmilovic Z, Maras V. Role of Danube inland navigation in Europe. International Journal for Traffic and Transport Engineering 2011; 1(1): 28-40.

Radonjic A. Strategy to reduce pollution from Serbian pushboats. International Journal for Traffic and Transport Engineering 2011; 1(2): 59-72.

Radojcic D. Environmentally friendly inland waterway ship design for the Danube River. Final Report of the "Danube Navigation" project, World Wide Fund for Nature International and Danube-Carpathian Programme (WWF-DCP). 2009.

UNCTAD Review of Maritime Transport 2013, 2013, Geneva.