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Sustainability of Motorways of the Sea and Fast Ships

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ABSTRACT: The European transport policy undertakes to enhance sustainability in transport in order to boost economic activities in the whole EU. The reduction of pollutant emissions and a better balance among modes of transportation to cut road congestion are the pillars of the above policy. These factors are encouraging public and private stakeholders to use the freight maritime alternative more extensively. Short sea shipping is considered the quickest way to reach sustainability. Another advantage of ships over trucks and trains is that vessels consume less fuel as a result of the relatively low speeds at which they travel. However, increasingly faster ships are in a position to compete with trucks, but the former's greater power demand and consumption rate result in higher pollutant emission levels which, in turn, lead to the loss of their environmental advantage over road transport. This problem is analyzed below.

1 INTRODUCTION

According to the mid-term review of the EU White Paper on Transport, Short Sea Shipping is expected to grow at a rate of 59% (metric tonnes) between 2000 and 2020. If we consider that the overall expected increase in both freight exchanges and volume is 50%, sea transport appears as one of the most feasible options to reduce traffic congestion on European roads. However, this alternative has not been definitely adopted because of technical, administrative and legal reasons. Moreover, society still regards maritime transport as a slow, inefficient mode since shippers do not yet offer the best value for money. Infrastructures need to be balanced by using tariff principles which reflect the exact external costs incurred by these infrastructures. Along this line of action, in 1998 the European Union published the White Paper on Fair Payment for Infrastructure Use: A Phased Approach to a Common Transport Infrastructure Charging Framework in the EU COM (1998) 466. This paper analyzes selected intermodal transport chains and pollutant emissions from different power output ships, and compares them with those generated by road transport. These emissions are then translated into environmental costs, based on existing quantification databases. In some cases, maritime transport proves to be a better alternative, justifying the granting of some kind of environmental bonus by the administration to promote the sea option. The paper concludes with a brief discussion on how to best implement this bonus to achieve a real balance between transport modes.

2 SCENARIO

In 1998, the European Union published the White Paper on Fair Payment for Infrastructure Use: A Phased Approach to a Common Transport Infrastructure Charging Framework in the EU COM (1998) 466, where "the user pays" and "the polluter pays" principles were established. It was initially suggested that dues charged on vehicles having a maximum payload of over 12 metric tonnes should be based on marginal infrastructure costs per kilometre and marginal urban congestion costs. The first tariff scheme for infrastructure use proposed in studies conducted in Europe like DESIRE (2001) and INFRAS (2004) was meant to be implemented in Germany in 2003 with an initial tariff of 0.17 €/km on all vehicle and truck units with a maximum loading capacity exceeding 12 metric tonnes passing through or delivering goods in Germany. However, after repeated delays, it was in 2005 that the scheme was launched with a tariff of 0.124 €/km. In 2007 the average rate increased to 0.135 €/km and tariffs were reviewed again in October 2008. As far as waste gas emissions are concerned, charges depend on the exact number of kilometers travelled on paid motorway sections, number of vehicle axes and engine class. Regarding pollutant emissions, in 1988 the European Parliament adopted the first Euro regulation, followed by Euro II, III and IV. Euro V and VI are increasingly stricter regulations on vehicle pollutant emissions, in particular particle emissions and nitrogen oxides (NOx) limits. Coming into force on 1st September 2009, Euro V establishes an 80% decrease in particle emission limits, which implies the need for future fitting of particle filters in vehicles. Euro VI will come into force in 2014 and impose limits of up to 68% of current levels on oxides. Maritime transport emissions are mainly regulated by the MARPOL Convention and some specific European regulations. The new directives concerning SO_2 and NO_x maximum emission levels aim to reduce these chemical compounds, which will be the weak point of maritime transport in the future. Of all modes of transport, the maritime one is responsible for the largest amount of SO_2 emitted into the atmosphere, only to be compensated by the use of low sulphur content fuels or exhaust gas cleaning systems. However, sulphur emissions from maritime transport account for 6% to 12% of total anthropogenic emissions only (Chengfeng 2007). Despite this scenario, in 2000 about 44% of total NOx emissions into the atmosphere in Europe were attributable to road transport and 36% to maritime transport (TERM 2002). Road transport is the main source of CO_2 emissions, contributing 91.7% of total EU transport greenhouse gas emissions. When including sea shipping in a breakdown of transport-related CO_2 emissions, it appears that in Europe maritime transport accounts for only about 6% of total greenhouse gas emissions, which explains the interest in reducing the share of road transport. Annex VI to the MARPOL Convention and the NOx technical code amendments were approved at the Maritime and Environment Protection Committee (MEPC) 58th session (October 2008), following the draft amendments on prevention of air pollution from ships agreed by the IMO Sub-Committee on Bulk and Liquid Gases (BLG) at its 12th session, held in February, and further agreed at the MEPC 57th session (April 2008).

2.1 *Environmental credentials of sea transport*

Maritime transport is one of the least pollutant modes. Additionally, it contributes to the reduction of traffic congestion, accidents and noise costs on European roadways (European Commission 2001). This justifies support actions to intermodal chains with marine sections including short sea shipping links as a way to reach more sustainable mobility within Europe. Nevertheless, a transport policy based solely on tariff measures will not provide the desired modal shift because users must see alternative transport modes as an efficient and quality choice. All administrative bodies should work cooperatively to improve intermodal infrastructures such as port and rail intermodal links or to simplify or speed up all document dispatch processes in maritime transport.

3 STUDY OF THE MARINE ALTERNATIVE

Due to patent medium-term rail transport limitations generated by the lack of coordination among all involved countries in terms of investment, mutual recognition of engineering licenses, unification of signal systems and standardization of electrical power distribution systems, short sea shipping is considered the best short-term option. The concept of short sea shipping is defined in the COM (1999) 317 "The Development of Short Sea Shipping in Europe" final document as the *transport by sea of goods and passengers, between ports geographically placed in Europe or between those ports and other ones located in coastal countries of the closed seas surrounding Europe*. This means that this mode of transport integrates the following aspects: roll on roll off traffic, general cargo traffic including containers, liquid and solid bulk and even neobulk traffic, passenger transport and feeder services.

In this sense, all selected target routes, i.e. the five most efficient in INECEU (2005) and ANTARES (2007) studies, leave from Iberian Peninsula ports and have different destinations in Western Europe (Table 1).

Table 1: Routes obtained from the ANTARES study. Source: own data.

Route	Origin		Destination	
	Origin	Port	Port	Destination
Route 1	Madrid	Valencia	Naples	Naples
Route 2	Barcelona	Barcelona	Civitavec.	Rome
Route 3	Alicante	Alicante	Genoa	Milan
Route 4	Burgos	Tarragona	Genoa	Milan
Route 5	Zamora	Gijon	Hamburg	Berlin

Keeping in mind the above intermodal routes, the following criteria were used in our study:

1 Costs were divided into two main categories: external environmental costs, derived from local air pollution, global warming and noise pollution, and external non-environmental costs, derived from accidents and traffic congestion.
2 To evaluate the impact of the evolution of transport-related emissions, the scenario considered is a future hypothetical improved condition where future stricter regulations, like Euro IV, are applied to road (in force as of 2006 for new trucks and shown in table 6) and maritime transport, resulting in a 10% decrease in all current emissions, except for S, SO2 and NOx.

Table 2: Emission rates for diesel Euro IV road and sea transport. Source: own, based on ICF model from REALISE, 2005.

Emitted gases	Road	Short Sea Shipping
	Euro IV (g/Kg fuel)	Improved (g/Kg fuel)
SO_2	0.114	30
NO_x	28.125	19.36
CO	5.75	8.1
Nm-VOC	2.316	2.466
PM	0.45	6.84
CH_4	0.095	0.099
CO_2	3,323	2,853
S	0.05	15

3 The cargo capacities of the selected Ro/Pax ships are considered, bearing in mind that they are real ships serving short sea shipping traffics in SW Europe. The three ships are an example of each speed group: conventional Ro/Pax vessels are represented by ship A, fast Ro/Pax vessels by ship B and high speed craft by ship C (Table 3) (Martínez de Osés & Castells 2008). Cargo capacity was calculated dividing the ship's total linear capacity by 19.5 meters (European Commission 2002), including the number of trucks (assumed FEUs) that the ship is capable of carrying. Cargo is measured in FEU (very close to trailer length) as it is the common unit of freight in sea and road legs, assuming the container to be filled to 60% of its full capacity (Martínez de Osés & Castells 2008).

Table 3: Main particulars of selected ships. Source: own, based on shipping company information.

Particulars	Conventional	Fast Conventional.	HSC
	Ship A	Ship B	Ship C
Type	RoRo/Pax	RoRo/Pax	Ro/Pax
DWT (Tm)	13274	5717	1076
GT	25058	23933	8089
Speed (knots)	18	27	40
Capacity (l.m.)	2600	1700	450
Trailers (19.5m)	133	97	23
Cars (units)	124	100	123
Passengers	500	1400	1291
Power (kW.)	24000	31680	32800

4 The main engine specific fuel consumption rate is strongly affected by the installed propulsion systems, such as engine, gear, shaft and propulsion arrangements. Nevertheless, modern diesel engines use half the fuel consumed daily by old inefficient steam engines with the same power outtake (Endresen 2007).

Although the total fuel consumption rate depends on the engine's maximum output, the average power is assumed to be 85% of MCR (Maximum Continuous Rate) of installed power. However, the average main engine load and speed vary dramatically for different ship types. Some authors have reported an average load of 80% MCR based on statistical data. For example, bulk carriers tend to have slightly lower average values (72% MCR) than tankers (84% MCR). Accordingly, load can range from about 60% MCR up to 95% MCR for the analysed ships (Floedstroem 1997). For our purposes, engine load was fixed to 80% of engine load when sailing and 20% for time spent at ports due to operations (Endresen 2007).

Table 4: Hourly consumption based on engine load and power. Source: own data.

Type of ship	Speed	Consumption (Tm/hour)	
	In knots	80% MCR	20% MCR
Conventional	20	3.84	0.96
Fast conventional	27	8.068	2.017
High speed craft	40	5.25	1.312

5 The emission factors considered in our study are taken from the REALISE database. The advantage in CO2 emission factors in maritime transport lies in that ships consume less power than trucks to carry the same amount of cargo. However, as ship speed increases, the difference can be negligible and even negative. Additionally, because of the sulphur content of marine fuels, sulphurous emissions are still the weak point of maritime transport. A global average of 2.5% sulphur content is assumed, ranging from 0.5% for distillates to 2.7% for heavy fuel. We must emphasize that high-viscosity heavy fuel tends to have higher sulphur values than low-viscosity fuels. At this point, the question arises whether it is still feasible to propose an environmental bonus for trucks boarding a ship as ships have lesser pollutant effects per tonne and kilometre travelled than trucks.

4 PRELIMINARY RESULTS

Conventional ships are the most efficient type as far as pollutant emissions are concerned because they have the lowest consumption rates but also the lowest developed speed. Table 5 compares external cost savings of each ship type at only 60% of cargo capacity with those of road-only transport resulting from road distance not being covered.

Table 5: Total external costs of the unimodal or sea-only intermodal solutions, taking the 200 g/h kW consumption rate for the Ro/Pax ships A, B and C in route 1 (Source: own, based on pricing costs from REALISE, 2005).

Type of ship	Potential saving € / FEU	Potential saving € / FEU x km
Conventional	310.9	0.1477
Fast conventional	-16.08	-0.0076
High Speed Craft	-1,542.97	-0.733

These external cost savings could justify the proposal of an environmental bonus to encourage freight transport companies to ship their trucks instead of travelling the same route by road only. In the case of the fastest ships, their smaller cargo capacity results in noticeably poor environmental performances, leading to even negative saving rates compared with truck emissions for the same route. Keeping in mind only the scenario where ship A is compared with road transport as being the only marine option providing external costs savings, the bonus potentially offered by the administration to the truck company would be a maximum of 14.7 cents per kilometre not travelled by the truck. Nonetheless, some authors (e.g. García Menéndez, Martínez and Piñero 2003, and Pérez 2004) found that, as far as modal shift is concerned, the maritime share would grow in a higher proportion as result of an increase in road transport cost rather than a decrease in the price of freight. Crossed elasticity in the choice of maritime transport over road transport is about 1.075%; that is, the probability of selecting maritime transport increases by 1.075% for each 1% of road transport cost increase. An improvement of customer service or faster customs procedures in maritime transport results in an elasticity rate of about 0.641%. This means that a reduction in freight transport costs of approximately 1% would increase the probability of choosing sea transport by 0.641% only.

5 CONCLUSIONS

The intermodal option provides hardly any external cost savings for the five routes because the difference between road and sea distances is sometimes negligible. In addition, road legs in intermodal chains are too long, and increasing oil prices pose a threat to high speed crafts, which are heavily penalized for their high consumption rates, which lead to higher operational costs. Furthermore, there is concern about poor environmental performance. Conventional ships are the most environmentally friendly ones, the difference between fast conventional and high speed crafts being bigger than between conventional and fast conventional ships. This slight advantage of conventional ships would be eliminated if stricter regulations (Euro VI) for road transport were applied, particularly if no other measure is taken for sea transport. However, the better environmental performance of ships serving specific intermodal transport routes could justify the allocation of public grants as an economic incentive to convince users to choose maritime transport. An example is the environmental bonus offered by the Italian government in several routes to endorse trailers and trucks boarding ships instead of covering routes by road only. This action has also been taken by the Basque autonomous government in Spain.

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