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THE INLAND NAVIGATION IN EUROPE: BASIC FACTS, ADVANTAGES AND DISADVANTAGES

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Abstract

The inland waterway cargo transport in Europe is very competitive in relation to other, surface types of transport. Compositions of pushed barges can generate more ton-kilometers per distance unit then any other type of surface transport. Only pipeline transportation is more cost-effective than inland navigation, but it also has certain disadvantages like volume of investment, capability of only one type of liquid cargo (mostly crude oil), need for the flow to be always constant and to correspond to the full nominal capacity and travel conditions that reduce its flexibility. The development of this type of traffic in Europe was not satisfactory since its share according to traffic modal split was decreasing in the course of the last decades as a result of very rapid development of the road transportation. Circulation volume in tons on the inland waterways is significantly changing in very wide range from one European country to the other. It is, for example, very high in the Rhine region, while on the Danube it is app. 10 % of the possible throughput capacity of this navigable way.

This paper deals with advantages and disadvantages of the inland navigation, as well as, some specific characteristics of inland waterway cargo transport on main inland waterways in Europe.

Key Words: Inland navigation in Europe, Inland shipping, Specific characteristics of inland waterway cargo transport.

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GENERAL CONSIDERATION

Inland water transportation or inland navigation is very significant mode of cargo transportation, its role is locally significant for the passenger transportation in comparison to other inland modes. Major industries, business and service activities owe much of its survival and progress to low cost of raw materials, semi – finished products, energy, containers and other load units. Some industrial sectors may reach market only via inland waterway transport, since the other transport modes are unacceptable. For example, the construction industry, mining, forestry, metallurgy, chemical and oil industry, electrical power generation and agriculture are among those sectors that depend closely on the inland waterway transport. A large part of world industry and service rendering activities are developed on the water due to transportation and water supply at sites along navigable inland waterways. Industry was built logically where there are low transportation costs and low costs of trans-loading from self-propelled and non-self-propelled barges and vessels.

Inland waterway transportation includes the oldest and most progressive sector that has expanded from primitive vessels to highly automated pushers, which push compositions of barges loaded by tens of tones on the big rivers. Contemporary technology allows full integration of inland navigation with all inland transport modes and overseas navigation. For cargo to be transported and trans-loaded in large volumes does not require an extremely precise transportation schedule, the inland waterway transportation provides services at prices lower (by up to 30%) than the other modes of transportation. In inter-modal connection, highly cost-effective inland waterway transportation combined with faster railways and more elastic road transportation, seems to be the only solution in transport chains involving, for example, large number of containers.

The inland waterway transportation, oldest of all transport modes, depends considerably on environmental conditions like depth and width of the waterway, streams and their velocity, variation of water levels, radii of bends, maintenance and equipment of navigational aids; level of use of information and management systems; port equipment and capabilities, as well as from the market conditions. It requires relatively high investments in development of infrastructure on which quality mainly depends. By the condition of the infrastructure it is possible to observe the potential of this mode in a certain region (Radmilović, 2005).

The traffic load of the European navigable inland ways, total volume of the load divided with the total length of the navigable way in t/km shows that the highest rate of use of the navigable inland waterways is realized in Belgium, Holland and Germany. The traffic load of the Rhine is ten times higher than that of the Danube, which shows that the transportation capacities of the Danube are used extremely little (White paper, 1996; EUDET, 1999).

On the navigable inland waterways in Europe, which are open to the international traffic, the ships under foreign flags transport much larger volumes than ships with domestic flags.

BASIC FACTS INFLUENCING THE DEVELOPMENT OF THE INLAND WATERWAY TRANSPORT

Inland navigation is very competitive in relation to other inland transport modes. Pushed tow of barges can generate more ton – kilometers per distance unit than any other mode of the surface transport modes. Only pipeline transportation is more cost – effective than inland navigation, but it also has certain disadvantages like volume of investment, capability of only one type of liquid cargo (mostly crude oil and gas), need for the flow to be always constant and to correspond to the full nominal capacity and travel conditions that reduce its flexibility. All these results in transportation of the liquid cargo by inland waterways very often being more cost-effective that by the pipeline.

Advantages of the Inland Navigation

According to the data of the Economic Commission for Europe, Committee for Inland Transport of the United Nations operating from Geneva, Commission of the Transportation Ministries of the European Community Member Countries, various national associations and scientific organizations in the European countries, the advantages of the inland waterway transportation are the following ones:

1. Cost effectiveness.
2. Least consumption of the propulsion energy.
3. Least quantity of the material needed for the construction of the transportation means per ton of the transported cargo.
4. Navigational safety.
5. Environmentally most friendly type of cargo transportation.
6. Least land (soil) use.

It has to be noted that the specified advantages are interdependent and that between them multilayered relations and influences exist as well as that some advantages have to be proved when compared and quantified under real conditions in relation to other modes of the surface transport (Radmilović, 2005).

Overview of the cost effectiveness of the inland waterway transportation can be obtained through various indicators and relations. For example, group (tow) of two pushed barges of EUROPE II type with loading capacity 4400 tons is according to its transportation capacity equal to the load bearing capacity of 110 railway cars of individual capacity 40 t or 220 trucks of individual load bearing capacity of 20 t. The specific investment costs are least in inland waterway transportation, since the propulsion power of 1 kW transports on average 150 kg load by truck, 500 kg by railway and 4000 kg by the cargo ship or towboat and barge group (White paper, 1996).

The life period of the ship is 1.5 times longer than that of the railway car and over 5 times longer than that of the truck. According to German statistical data the transportation costs equivalent to 1 tkm in road transportation are € 12.15, in railway transportation are € 6.35 and in inland navigation € 1.95 (White paper, 1996).

Fifteen years experience in the operation of the navigable waterway Rhine-Main-Danube has confirmed the advantages of the inland navigation over the railway transportation. For example, the German Railways have reduced by 50 % tariffs for the transportation of grain on the Hamburg – Bamberg line as well as for the transportation of fodder on the line Hamburg – Nurnberg. The shipping company "Preumesser" charges for its services on the line Dunajvaros (Hungary) – Duisburg (Germany) on average 28.5 €/t while Austrian railway tariff the same services 71.5 €/t. Tariffs of the direct container line from the Danube ports in Austria to Hamburg and Rotterdam are 10-20 % lower than in case of railway transportation. On the Rhine the price for transportation of one TEU container on the line Strasbourg-Rotterdam/Antwerp is € 400 by inland waterways, € 917 by railway and € 800 by road (White paper, 1996).

Major economic advantage has the inland waterway transportation as compared to surface types in respect to costs of the part of infrastructure related to the use of the natural navigable waterways due to the fact that it does not burden the inland waterway traffic as in case of railway and road communications. However, on the artificial navigable waterways (channels) and channeled rivers with a large number of locks the competitiveness of the inland waterway traffic is diminished. It is anyway rarely the primary or the secondary main user in respect to intensity and significance of use of these waterways and waters those being rather the water economy, agriculture, electrical power generation etc.

The inland waterway transportation is the most economical type of traffic in respect to external and infrastructural costs. It has to be pointed out though that the evaluation of the transportation cost-effectiveness is highly dependent on the particular situation (Hilling, 1995; ECORYS Transport and METTLE, 2005; NAIADES, 2006).

The least consumption of the propulsion energy results from low needs of power in ships per unit of the transported cargo. According to the data of the USA Ministry of Transportation most economical propulsion units for the cargo transportation are large towed groups. The towed group with one liter of fuel effects on average 127.5 tkm, whereby with the same liter only 76 tkm are realized in case of railway traffic and only 23 tkm with average load by road (US Department of Transportation, 1994).

The comparison was made for the most represented, according to the load capacity, towed groups, railway compositions and road vehicles. For those transportation means the average power per cargo unit was within the following limits: 0.125 to 0.4 kW/t for inland ships, 0.588 to 1.91 for railway trains and 5.145 kW/t for road vehicles.

According to the data of the Royal Commission for Environmental Contamination Monitoring in Great Britain the use of energy per tkm according to the transport mode is as follows (Hilling, 1995):

	KJ/tkm
By air	15839
By road	2890
By rail	677
By river	423
By pipeline	168

According to the tkm made, the inland waterway transport is 1.6 times more efficient than the railway transportation and close to seven times than the road transport. Due to this the inland waterway transportation is emphasized and supported within the state energy conservation policy. The consumption of the propulsion energy in inland waterway transport depends to large extent on features and regulation of the navigable waterway because for higher velocities of the river flows larger power of the ship is needed, generally with limitation of its dimensions (draft, width and length). Similar situation is also with other transport modes where the road conditions are complex and severe.

In some cases the advantage of the railway transportation is emphasized over the inland waterway and road transport due to use of various or domestic energy sources (electrical power). However, in this case relatively high investment costs are needed for the necessary infrastructure in order that electric propulsion could be used as well as assessment of the external costs of contamination by power plants and electrical power supply implementation.

As an indicator of the competitiveness of the inland waterway transport in the intermodal transportation chains often is demonstrated the specific energy consumption per tkm, for example, for:

— Local transportation
  Truck 2.5 t (2210 Wh/tkm), truck 16 t (630 Wh/tkm);
— Long distance transportation
  Tractor with semi-trailer 38 t (300-325 Wh/tkm)
  Container river-road transportation: downstream/upstream (87-130/210-250 Wh/tkm)
  Hucke pack (240-280 Wh/tkm).

This means that in intermodal and multimodal transportation the reduction of the energy consumption on transportation chains is felt when inland navigation is included (White paper, 1996).

The least quantity of material for construction of the transportation means concerns the inland ships. They require less built-in steel per ton of the transported cargo than the railway cars, providing saving of the primary materials as well as energy and other production means. According to the USA Ministry of Transportation the barges require only 170 kg of ship construction steel per ton of the load capacity, while for the railway cars 250 kg per ton of the carrying load is needed. This is clearly reflected in the construction price of the barges and railway cars for bulk cargo, which according to USA prices have ratio of 1:3 to the advantage of the towboats (US Department of Transportation, 1994).

Navigation safety on the inland waterways is extremely high, which is partially result of relatively low traffic density as compared with other surface types. Accidents, causing major damages or injury of persons, are rare in the inland waterway traffic. This advantage is of particular significance for the transportation of hazardous cargo, when the transportation involves large annual quantities.

Environmentally friendliest type of cargo transportation is the inland waterway traffic as cleanest type of traffic which helps improve the quality of human life, flora and fauna.

The contamination of the water, air and noise generated by the ships used for inland waterway navigation are insignificant as compared to other modes of surface transportation. According to various analysis the inland waterway traffic has lower degree of contamination of air than railway, though it may use significant part of electric power from hydroelectric and nuclear power plants for which it is considered that they do not contaminate the environment like thermal power plants.

The traffic and transportation are the most significant sources of the air contamination and they are, according to the data of the Royal Commission for Environmental Contamination Monitoring in Great Britain, responsible for 90 % of carbon-monoxide, 57 % of nitrogen oxides, 48 % of particles, 38 % of volatile organic compounds and 4 % of sulfur dioxide in the total air contamination (Hilling, 1995).

According to data of USA Ministry of Transportation the annual emission in the Saint Louis region as reference area are shown in the Table 1 (US Department of Transportation, 1994).

Type (source) of Emission	Towed Groups (tons)	Other Types of Surface Traffic (tons)	Total Emission (tons)
Nitrogen Oxides	3297	105932	433637
Hydrocarbons	939	198603	295124
Carbon Monoxide	2101	980944	3852753
Sulfur-Dioxide	462	7887	1234395
Particles	198	8940	354672

Table 1. Air Quality Control in the Saint Louis region in 1992

The extent of role of the inland waterway traffic for the air cleanliness protection can be seen from this table. According to the calculations of the German Ministry of

Transportation, the construction of the Mittelland and Elba-Havel channel would reduce the carbon monoxide emission by 200 000 t/year. According to the Austrian estimates, increased rate of use if the inland waterway traffic on Danube could create savings of 150 Million Euros reducing by this sum the costs of the carbon monoxide emission within traffic and transportation system (White paper, 1996).

Since the traffic and transportation cause irreversible climatic changes, generate and encourage other forms of contamination and cause damage to the human health and quality of life, the criteria for so called outside or external costs for each type of traffic are becoming decisive for the selection of any type of the cargo transport. In this sense the advantages of the inland waterway traffic are obvious as well as its relatively positive impact on the environment. The external costs, which include mostly the costs of contamination and jamming, are lowest for the inland waterway transport (ECORYS Transport and METTLE, 2005).

Land use of soil is a real advantage of the inland waterway transport. The soil is final resource and its use for the communications is limited due to adverse impact on the natural, human and cultural environment. The inland navigation has the only need for soil when artificial navigable waterways are constructed – channels and ports and piers. According to German calculations, for the same quantity of cargo, for the inland navigation is needed 30000 ha as compared to 84000 ha for railway and 290000 ha for the road transport (Binnenschiffahrt und Umwelt, 2005).

Disadvantages of the inland waterway navigation

The main disadvantages of the inland waterway navigation are the following ones:

1. Limited geographic expansion
2. Pronounced influence of current hydro-meteorological conditions
3. Quality level of the traffic service.

It has to be noted that above mentioned disadvantages are, similar like the advantages, interrelated and that between them complex links and influence exist, which have always to be reviewed from one case to another, in dependence on the actual conditions.

Limited geographic expansion concerns the natural spatial distribution and directions of the inland waterways. The base of the inland waterways consists of navigable rivers, which are by nature alone not interconnected, save for the tributaries. Their transformation into a network requires construction of the artificial channels across the watersheds, which is very expensive. According to the German Ministry of Transportation, the construction of the channel costs approximately € 13.75 Millions per one kilometer, the construction of the motorway ⊠ 5-10 Millions per km and that of the high speed railways app. ⊠ 17.5 Million per km (White paper, 1996).

The available network of the inland waterways does not cover always the main flows of goods. Consequently, it results that a particular problem with inland navigation are the costs of trans-loading and transfer from one mode (inland waterway transport) to other modes of the surface transport. The participation of the inland waterway traffic requires relatively higher degree of organization of the production in transportation chains.

Pronounced influence of current weather conditions may include the seasonal conditions (occurrence of low and high water, unmovable and movable ice and strong winds). The navigation in some sectors of the inland waterways may be subject to current weather and hydrology conditions, which are very difficult to overcome even at relatively high costs. Since there is no alternative, serious traffic breaks may occur reducing the cost-effectiveness and reliability of the inland navigation.

Quality level of the traffic service depends on the transportation reliability, speed, capability of "door to door" cargo transportation, safety, security, flexibility, availability and energy efficiency. The traffic service quality of inland navigation is characterized by certain features when compared to road and railway traffic. The reliability of the transportation depends on technical and operational conditions on the navigable waterway, which may be variable and impose limitations in respect to ship loading and number of vessels in the group. "Door to door" cargo transportation capability is the least in the inland waterway transport and most frequently distribution transportation chains have to be organized to and from ports using road and/or railway transport. According to other elements of the traffic service quality the inland waterway traffic is or at advantage or at the service level provided by other surface traffic modes, since for this type there is practically no jamming (new shipping is possible at any time) and the transit time can be reliably planned.

Misconceptions about the inland waterway navigation

Inland waterway traffic is slow. Inland navigation ships have speed in the range between 10 and 20 km/h, which is much lower than the speed of trains or road vehicles. However, the speed element speaking against the inland waterway traffic is often exaggerated. If the comparison is made using so called "commercial speed" it may be seen that under present conditions all types of the surface traffic are relatively equal, in particular in case of the long-distance transportation. Inland navigation ships operate continually during 24 hours and they are entirely adapted to observing the navigation time table and cargo delivery deadlines. According to Austrian Ministry of Transportation, Innovation and Technology the commercial speed in the road transportation between Europe and Greece is small, 12 km/h, while between Antwerp and Rome it reaches 20 km/h. Each increase of demand for certain time related delivery of cargo obviously compensates for the disadvantages of the inland navigation related to cargo. It is a fact that in the contemporary traffic and transportation system the speed of the transportation means is not of great significance within good logistic chain but rather the regularity and reliability of the service. Contemporary inland water transportation is capable to fulfill those requirements though the reliability can be sometimes insufficient as compared to other surface transportation modes (White paper, 1996).

Type of cargo is of decisive influence for the choice of the inland water navigation as the main transportation carrier in the surface transportation chains. The inland water transportation is the primary transportation system for bulk and liquid freight in large quantities. However, the nature of the cargo is not essential for the inland waterway transport being the most suitable type of transport irrelevant of the fact that it is traditionally used for the transportation of cargo for the needs of civil engineering, metallurgy, agriculture, oil and chemical industry. The best example for that is rapid growth of container traffic on the Rhine, which has now reached 2 000 000 TEU/year and RO/RO traffic (Seitz, 2006).

The role of the inland waterway traffic as inexpensive and safe transportation shall be always significant for the transportation of all types of cargo in large quantities and shipments. The internal criteria which significantly influence the choice of the inland waterway transportation as the main mode are the following ones:

1. Ports and piers adequately enabled for the reception and dispatching of the cargo by inland navigation vessels
2. Flows of goods stable in time and regular supply with cargo
3. Navigable waterways which allow navigation of corresponding ships and groups
4. Level of use and development of the information and control systems.

Inland waterway transport is isolated and out-dated technology system. If observed isolated the inland waterway transport may seem inferior in relation to road or, up to a point, to railway transport. This is explained by the fact that the network of inland navigable waterways are geographically fixed mostly for plain regions, that it is extremely difficult and expensive to interconnect them, which results in them being of only regional and local significant. Great differences in navigation conditions on large navigable waterways (upper, middle and lower sectors) and on the network in general have adverse effect on the inland navigation and use of ships and ports and piers.

Today is the main goal of the transport policy, at continual and rapid growth of the cargo traffic, such type of traffic, which makes least environmental damage and uses the existing infrastructure as less as possible. In this sense, there is no doubt that the transportation by water in general is the least damaging mode and that its natural infrastructure can be most efficiently used.

SOME SPECIFIC CHARACTERISTICS OF INLAND WATERWAY CARGO TRANSPORTATION IN EUROPE

The European network of inland waterways can be divided on four separated and relatively connected navigable systems such as:

— Northwest navigable system (with main rivers: Rhine, Elba, Odra, Vistula (Wisla) and other rivers and canals)
— Southwest navigable system (with main rivers: Rhone, Seine, Saone, Marna and other small rivers and canals)
— Danubean navigable system (with tributaries and canals)
— East navigable system (Volga, Dnepr, Dniester, Don and other rivers, canals and lakes).

Also, the inland waterway cargo fleet can be divided depending on the transportation technology as follows (see Fig. 1):

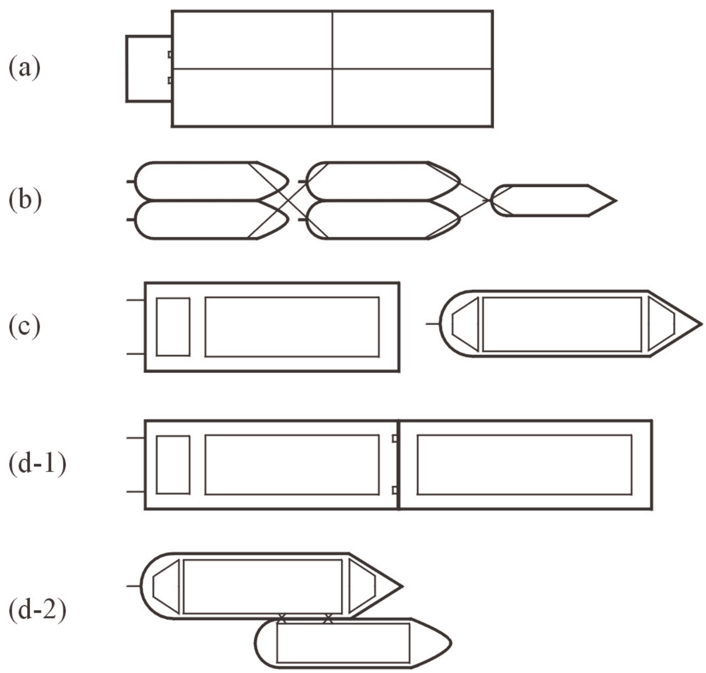

Fig. 1. Transport fleet and Types of Vessels in Inland Navigation in Europe, (a) Pushed barge tow with push-boat; (b) Pulled barge tow with pull tug; (c) Self-propelled barge or motor cargo ship; (d) 1 – Self-propelled pushed barge with pushed barge in tow; 2 – Self-propelled pulled barge with pulled barge in tow

All types of the above mentioned vessels in the inland waterway transport fleet exist on the European inland waterways. However, the pull-towing system is gradually being abandoned and only the existing fleet of pulltugs and pulled barges are in operation. These floating units are being replaced by pushboats and pushed barges, and, in smaller number of cases, by self-propelled barges (the Danube River is taken as example). These replacements depend on the class and hydro-meteorological conditions of the waterway, service quality in transport, cargo type, etc.

According to the presented researches and exploitation results, the push-towing system has no advantages in comparison with the self-propelled barge system in the European system of inland waterways. However, each system has its pros and cons, depending on numerous conditions (e.g. the minimum navigable depth and width of waterways, minimum width of turning areas, minimum equipment with navigational aids), (Radmilović et al., 1998; Radmilović et al., 2003).

On the basis of experiences gained at the European navigable network, there are a significant number of important advantages of push-towing system on all major waterways with the official waterway classification “IV” and above. Self-propelled barges have a great advantage, because of their high degree of flexibility. These vessels can reach almost any inland harbour on canal network.

As shown in Fig. 1, the power unit or motor ship and ship cargo space link in inland navigation can be divided into two groups: rigid and flexible. Rigid link, established between power unit and cargo space is dominant in maritime and road transport (sea ships and trucks), and occasionally in transport on inland waterways (self-propelled barges). Flexible link is used in railroad transport (between the locomotive and rail-road units), partially in road transport (systems with trailers and semi-trailers) and in inland waterway transport (push-towing, pulling systems and combinations of these systems).

Rigid link power unit has less exploitation time, since it has to wait along with ship cargo space at loading and unloading points (ports), depending on technology used, transportation process geography, and other operations (customs controls, change in transport conditions, etc.).

In the use of flexible link between power unit and cargo space, possibilities for higher exploitation time of power unit exist. This is true only for time periods during ship cargo space operations. For example, the motorboat and locomotive do not have to wait on tow or railcar units for cargo loading and unloading.

The self-propelled barge system is the simplest transport system, in an organizational sense, since the link that exists between the power unit and the cargo space is rigid. This system is the most frequent by used system in maritime transport, because these ships transport most of the total volume of cargo.

The pull-towing and push-towing systems are similar systems regarding transport operation, since they have non-rigid (flexible) connections between the power unit (pushboat or pull tug) and the cargo space (pushed and the pulled barge tows).

For example, in the inland waterway transport the pushboat-barge flexible link can operate as follows:

1. Continuous link between the pushboat and the barge tow;
2. Semi-continuous link between the pushboat and the barge tow;
3. Discontinuous link between the pushboat and the barge tow.

A continuous link (Fig. 2) is defined as an unruptured link between the pushboat and the barge tow during the traveling time and idle periods of the pushboat on the loading or unloading harbours or points, while the barges are served. The tow size or the number of barges in tow may be constant or variable values.

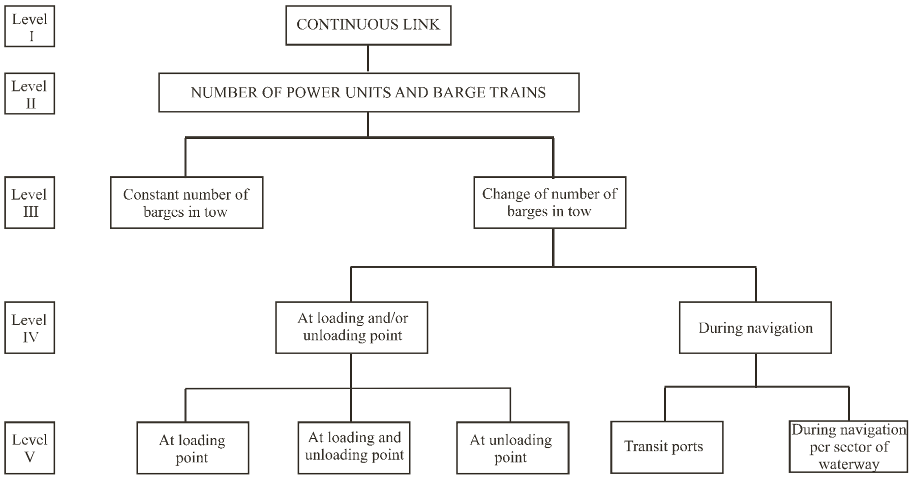

Fig. 2. Transportation's organization in continuous link between power unit (pushoboat) and cargo space (barge tow)

A semi-continuous link (Fig. 3) is defined as an unstable link between the pushboat and the barge tow. It means that the replacement of the pushboat can occur either during the traveling time, or at the loading or unloading points or harbours, and the pushing of barge tow by other pushboat. Like in the case one, the tow size or the number of barges in tow may be constant or variable values.

A discontinuous link (Fig. 3) represents the pushing of a barge tow with more than one pushboat. The replacement of the pushboat can occur during the traveling time and (or) at the loading/unloading points or harbours. Also, like as in the above mentioned cases, the tow size or number of barges in tow may be constant or variable values.

Two principles are obeyed in the definition of transportation organization. The first principle defines the number of ships or number of tows in operation. The second principle defines the number of barges in tow as a constant value or a variable.

Constant number of barges means the number of barges does not change at loading and unloading points and during the navigation (voyage).

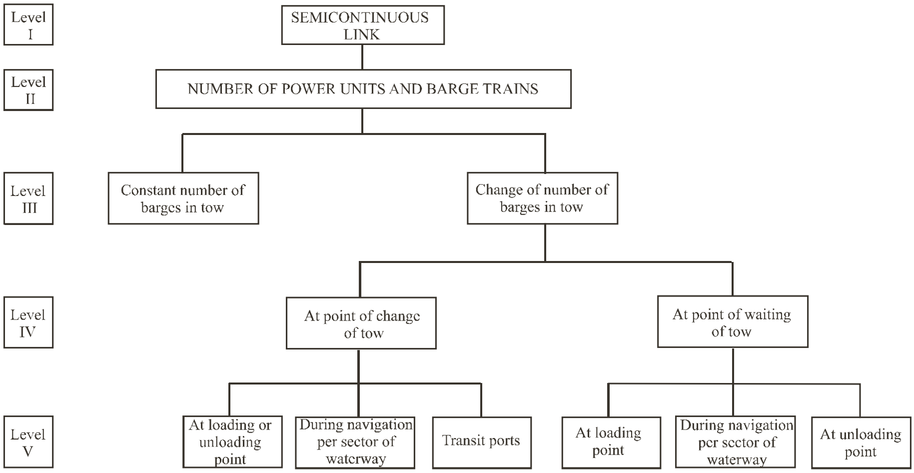

Fig. 3. Transportation's organization in semicontinuous link between power unit (pushoboat) and cargo space (barge tow)

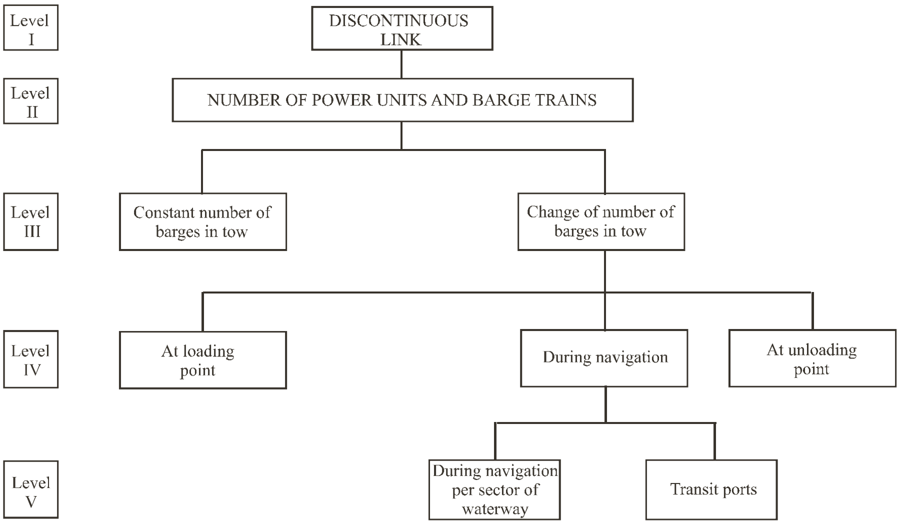

Fig. 3. Transportation's organization in discontinuous link between power unit (pushoboat) and cargo space (barge tow)

The variation in number of barges in tow means the tow size can change at loading/unloading points and during navigation.

Determination of the kind of link between the power unit and cargo space depends on the navigation conditions (change of classes of navigable waterways) and characteristics of cargo flows. For example, for longer waterway reaches in the case where navigation conditions can be rapidly changed, decision between non-disrupted or disrupted link should be made having in mind waiting costs of power unit or cargo space. In the case of favourable navigation conditions and when cargo flows are high-tonnage flows, it is necessary to make a decision on the type of link between power unit and cargo space. The type of link should depend on coordination between transport processes, cargo operation, port services, etc., or the ratio between travel time and standing time at the loading and unloading points or ports. The main objective is to ensure maximum exploitation of inland waterway ships per time, cargo capacity, power, and achievement of maximum transportation capacity.

CONCLUSION

For the European inland waterway transport, it is essential that a way be found to benefit from the strong advantages of this old transport system, i.e. transport of large volumes of cargo at low cost. This can be achieved mainly by organizational and technical adaptation in all basic parts: inland waterways, fleets and ports related to the intermodality and multimodality of inland waterway transport as a whole in Europe. Today, there are considerable differences between main rivers in Europe (in a view of methods of navigation, customs, degree of isolation and unequal share and distribution of cargo flows with the discrimination of inland waterway transport. Probably the inland waterway transport has big chance for its development in existing European transport network as trunk haul to the cargo transportation in many cases and countries with inland waterways, having in mind mentioned advantages, shortages and misconceptions.

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