

Economic geography and infrastructure of waterways

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1. Inland navigation in Europe

“A waterway is a body of surface water serving as a route of transport for goods and/or passengers by means of ships. Navigable inland transport routes are called inland waterways. Natural inland waterways are provided by rivers and lakes, whereas canals are artificial waterways. The European Agreement on Main Inland Waterways of International Importance (AGN) provides a classification of inland waterways.

The class of an inland waterway is determined by the maximum dimensions of the vessels which are able to operate on this waterway. The classification of the waterways, in the case of convoys, depends, beside the width and length and draught and tonnage, on the formation of the convoy. Restriction regarding the minimum draught loaded of vessels, which is set at 2.50 meters for an international waterway, as well as the minimum height under bridges (5.25 meters in relation to the highest navigable water level) can be made as an exception for existing waterways. As shown in Figure 1, depending on the waterway class, different formations and types of vessels are able to navigate on the corresponding waterway.”¹

Motor cargo vessels						
Type of vessel: general characteristics						
Water-way class	Designation	Max. length L (m)	Max. width B (m)	Draught d (m)	Deadweight T (t)	Min. height under bridges H (m)
IV	Johann Welker	80–85	9.5	2.5	1,000–1,500	5.25 / 7.00
Va	Large Rhine vessel	95–110	11.4	2.5–2.8	1,500–3,000	5.25 / 7.00 / 9.10
Vb	Large Rhine vessel	95–110	11.4	2.5–2.8	1,500–3,000	5.25 / 7.00 / 9.10
Vla	Large Rhine vessel	95–110	11.4	2.5–2.8	1,500–3,000	7.00 / 9.10
Vlb	Large Rhine vessel	140	15.0	3.9	1,500–3,000	7.00 / 9.10
Vlc	Large Rhine vessel	140	15.0	3.9	1,500–3,000	9.10
VII	Large Rhine vessel	140	15.0	3.9	1,500–3,000	9.10

Pushed convoys						
Type of convoys: general characteristics						
Water-way class	Formation	Length L (m)	Width B (m)	Draught d (m)	Deadweight T (t)	Min. height under bridges H (m)
IV		85	9.5	2.5–2.8	1,250–1,450	5.25 / 7.00
Va		95–110	11.4	2.5–4.5	1,600–3,000	5.25 / 7.00 / 9.10
Vb		172–185	11.4	2.5–4.5	3,200–6,000	5.25 / 7.00 / 9.10
Vla		95–110	22.8	2.5–4.5	3,200–6,000	7.00 / 9.10
Vlb		185–195	22.8	2.5–4.5	6,400–12,000	7.00 / 9.10
Vlc		270–280	22.8	2.5–4.5	9,600–18,000	9.10
		195–200	33.0–34.2	2.5–4.5	9,600–18,000	9.10
VII		275–285	33.0–34.2	2.5–4.5	14,500–27,000	9.10

Figure 1 - International waterway classes based on type of vessels and convoys (Source: United Nations Economic Commission for Europe 2010)²

“The E waterway network consists of European inland waterways and coastal routes which are of importance for international freight transport, including the ports situated on these waterways. E

¹ Cf. Dolinsek, et al., 2013, p. 44

² Cf. Dolinsek, et al., 2013, p. 45

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waterways are designed by the letter “E” followed by a number or a class of numbers, whereby main inland waterways are identified by two-digit numbers and branches by four or six-digit numbers. Waterway classes are identified by Roman numbers from I to VII. Waterways of class IV or higher are of economic importance to international freight transport. Classes I to III identify waterways of regional or national importance.”³

“The numbering of inland waterways of international importance, according to the AGN Convention, specifies that:

1. All inland waterways of international importance (E waterways) shall have two-, four- or six-digit numbers preceded by the letter "E".
2. Main elementary parts of the E waterway network shall have two-digit numbers and their branches and secondary branches ("branches of branches") shall have four- and six-digit numbers, respectively.
3. Main inland waterways which follow a mainly north-south direction providing access to sea ports and connecting one sea basin to another shall be numbered 10, 20, 30, 40 and 50 in ascending order from west to east.
4. Main inland waterways which follow a mainly west-east direction crossing three or more inland waterways mentioned in 3 above shall be numbered 60, 70, 80 and 90 in ascending order from north to south.
5. Other main inland waterways shall be identified by two-digit numbers between the numbers of the two main inland waterways, as mentioned in 3 and 4 above, between which they are located.
6. In the case of branches (or branches of branches), the first two (or four) digits shall indicate the relevant higher element of the waterway network and the last two shall indicate individual branches numbered in order from the beginning to the end of the higher element. Even numbers shall be used for right-hand-side branches and odd numbers for left-hand-side branches.”⁴

³ Cf. Dolinsek, et al., 2013, p. 44

⁴ United Nations Economic Commission for Europe, 1996, p. 10

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2. Comparison of European and international waterways

Due to geographical prerequisites, countries may have a lot or little available waterways. At a global level, China and Russia have the most available navigable waterways.⁵ Therefore, the prerequisites for inland navigation differ at continental and country level due to available navigable waterways.

Another factor that influences the use of inland waterways as a transport mode is their political importance. In Europe, inland waterways are important for freight transport. The European Commission aims to strengthen inland navigation through a variety of measures such as promotion programs and cost benefits.⁶ In China, water transport can also be seen as a very important part of freight transport. Inland waterways have been the most important transport mode for many years and consequently of economic importance.⁷ In contrast, in Brazil, inland waterways are not an important transport mode and waterway management is very inefficient.⁸

The political importance is also reflected by investments in transport infrastructure: In the period 1992-2011 China spent 8.5 % of its gross domestic product (GDP) on infrastructure investments (high percentage invested in road, power, rail and water infrastructure). In comparison, Europe spent 2.6 % of the GDP on infrastructure investments. In Brazil, investments in waterway infrastructure have a low priority. In general, Latin America only spent 1.8 % of its GDP on infrastructure investments.⁹

2.1. Inland Navigation in Europe

“The most important inland waterway axis on the European mainland is the Rhine-Main-Danube-Corridor. The Rhine and Danube river basins, which are connected by the Main-Danube Canal, are the backbone of this axis. The Main-Danube Corridor was opened to navigation in 1992 and created an international waterway between the North Sea and the Black Sea. This waterway has a total length of 3504 km and provides a waterway connection between 15 European countries. The navigable length of the Danube available to international waterway freight transport is 2415 km, starting from Sulina at the end of the middle Danube distributaries into the Black Sea in Romania (river-km 0) to the end of the Danube as German federal waterway at Kelheim (river-km 2415). The Kelheim-Sulina main route is subject to the Convention Regarding the Regime of Navigation on the Danube of the April 18th, 1948, which ensures free navigation on the Danube for all commercial vessels sailing under the flags of all nations.”¹⁰

In terms of average inflow, the five major tributaries of the Danube are the Sava, Tisa, Inn, Drava and Siret. Only Sava, Tisa and Drava are part of the corridor. The corridor connects the North Sea to the Black Sea, providing a navigable artery between the Rhine delta (at Rotterdam in the Netherlands), and

⁵ URL: <http://www.indexmundi.com/map/?t=10&v=116&r=xx&l=en> [29.07.2016]

⁶ URL: http://ec.europa.eu/transport/modes/inland/index_en.htm [29.07.2016]

⁷ URL: <https://www.britannica.com/place/China/Waterways> [29.07.2016]

⁸ Cf. Brazilian Ministry of Transport, 2013, p.30

⁹ URL: <http://www.mckinsey.com/global-themes/winning-in-emerging-markets/chinese-infrastructure-the-big-picture> [29.07.2016]

¹⁰ Cf. Dolinsek, et al., 2013, p. 46

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the Danube Delta in south-eastern Romania and south-western Ukraine (or Constanta, through the Danube–Black Sea Canal).¹¹

On its way from Germany to the Black Sea, the Danube passes through 10 riparian countries of which 6 are member of the EU. Romania has the largest share of the Danube (1,075 km) - almost a third of the total length. The shortest sectors on a country are on:¹²

- Slovakia – 61,70 km (km-1,872.70 to 1,811.00, on the right side)
- Ukraine – 133,59 km (km-133.59 to 0.00, on the left side)
- Croatia – 137,50 km (km-1,433.00 to 1,295.50, on the right side)



Figure 2 - Danube riparian states and common border stretches on the Danube waterway (Source: viadonau)

“According to the definition of the Danube Commission, the international Danube waterway can be subdivided into three main sections for which the nautical characteristics are provided in the following Figure 3. The division into three main sections is based in the physical-geographical characteristics of the Danube River.”¹³

¹¹ Cf. Dolinsek, et al., 2013, p. 41ff

¹² Cf. Dolinsek, et al., 2013, p. 40

¹³ Cf. Dolinsek, et al., 2013, p. 46

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	Upper Danube Kelheim – Gönyü	Central Danube Gönyü – Turnu-Severin	Lower Danube Turnu-Severin – Sulina
Length of section	624 km	860 km	931 km
River-km	2,414.72–1,791.33	1,791.33–931.00	931.00–0.00
Ø gradient per km	~ 37 cm	~ 8 cm	~ 4 cm
Height of fall	~ 232 m	~ 68 m	~ 39 m
Upstream travel speed of vessels	9–13 km/h	9–13 km/h	11–15 km/h
Downstream travel speed of vessels	16–18 km/h	18–20 km/h	18–20 km/h

Figure 3 - Nautical characteristics of the different Danube Sections (Source: viadonau, Danube Commission)

In 2010, 43 million tons of cargo were transported on an average distance of 600 kilometres.¹⁴ The most important market for freight transport on the **Danube** is the transport of iron and ferrous ores. Thus, the product category of ores and metal wastes can be identified as the most frequently transported goods on the Danube in 2014, followed by petroleum and agricultural products. Concerning the connection to other transport modes, there are different inland ports along the Danube as well as the maritime port in Constanta, where the highest volume of goods is transhipped.¹⁵

The route of the **Rhine** runs from Rotterdam (Netherlands) to Basel (Switzerland) and has a length of 885 km.¹⁶ Two third of all goods transported on inland waterways in Europe pass through the Rhine. This fact points out the importance of this inland waterway for the European economy and transport sector. The predominant transported goods in 2014 were solid mineral fuels, petroleum products and ores. The highest amount of goods is transhipped at the port of Duisburg (inland port) and at the port of Rotterdam (maritime port). The most important goods for transport on the Rhine are containers, weight-intensive goods and chemicals.¹⁷

Even though the **Danube** is 2.7 times longer than the **Rhine**, almost seven times more goods were transported on the Rhine in 2010. This is due to different infrastructural preconditions of these two inland waterways: The limited ramification of the Danube waterway enables only a spatially concentrated use, confining the Danube to a limited form of transport, requiring longer pre- and end-haulage by road or rail. For this reason, inland navigation in the Danube region usually has a lower share of national modal split figures. In addition, a total of 130 bridges span the international Danube waterway.¹⁸ This leads to restrictions concerning the possible transport volume of inland vessels. The economic activity and the high density of population along the Rhine also support an increased use of this inland waterway as a transport mode.¹⁹

¹⁴ Cf. Dolinsek, et al., 2013, p. 22f

¹⁵ URL: <http://www.inland-navigation.org/river/maindanube/> [29.07.2016]

¹⁶ Cf. Dolinsek, et al., 2013, p. 23

¹⁷ URL: <http://www.inland-navigation.org/river/rhine/> [29.07.2016]

¹⁸ Cf. Dolinsek, et al., 2013, p. 22f, 59

¹⁹ URL: <http://www.inland-navigation.org/river/rhine/> [29.07.2016]

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2.2. Inland navigation in China

Due to the longest waterway network with a total length of 123,495 kilometres, China has the largest network of inland waterways in the world. It consists of more than 5,000 rivers on which 1,180 million tons of cargo were transported in 2007.²⁰ Besides big maritime ports such as Shanghai, there are about 2,000 inland ports connecting inland waterways with other modes of transport.²¹ In the South there are larger rivers with stable fairway conditions which are not affected by the appearance of ice. In contrast, rivers located in the North are smaller and show unstable fairway conditions. In addition, during winter, the appearance of ice can affect inland waterway transport in this region.²²

Compared to other countries around the globe, China, in particular the port of Shanghai, has the highest container transshipment. In fact, in 2012, 32.6 million TEUs were handled in Shanghai (see Figure 4).²³

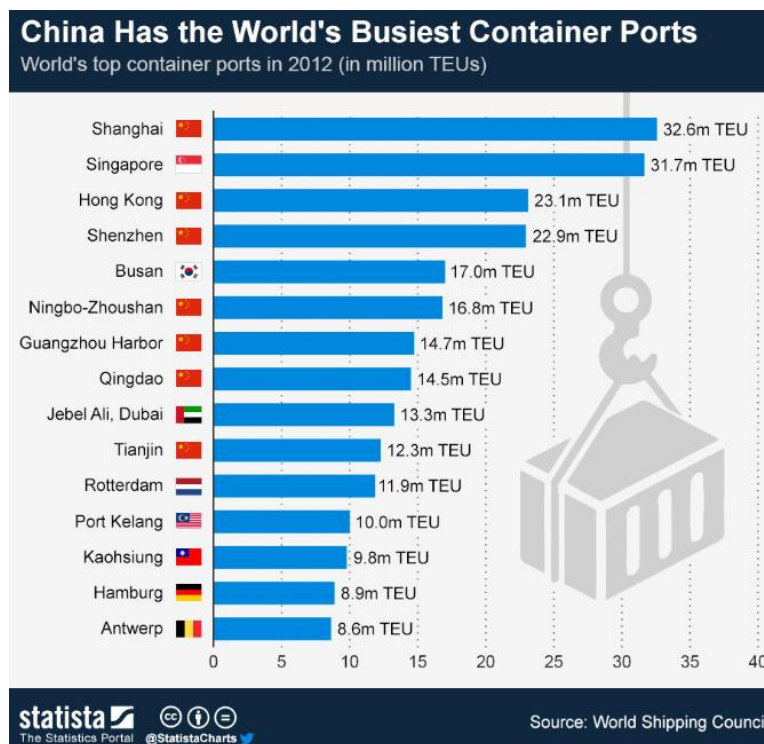


Figure 4 - Transshipment in ports around the world (in million TEU)²⁴

In 2007, more than three quarter of China's inland waterway transport volume of cargo was transported on three main waterways (**Yangtze River**, the Grand Canal and the Pearl River). Compared to the other two rivers, on the Yangtze River the highest volume (534 million tons) was transported and also the average transport distance in kilometres (378 km) was the highest.²⁵ The Yangtze River runs from the

²⁰ Cf. Urandaline Investments, no date, p. 237

²¹ Cf. ESCAP, 2014, p. 125

²² URL: <http://www.wwinn.org/china-inland-waterways> [29.07.2016]

²³ URL: <https://www.statista.com/chart/1488/china-has-the-worlds-busiest-container-ports/> [29.07.2016]

²⁴ URL: <https://www.statista.com/chart/1488/china-has-the-worlds-busiest-container-ports/> [29.07.2016]

²⁵ Cf. Urandaline Investments, no date, p. 239

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Himalaya to Shanghai and has a total length of more than 6,300 km of which 3,000 km are navigable.²⁶ Therefore, it is also the 3rd longest river, after the Nile and the Amazon, and largest river in the world. The Yangtze represents the main connection between rail, road and high-sea in China, enabling a wide intermodal transport network in China. Thus, also hinterland regions where an increasing number of industries are located are connected to maritime ports via the Yangtze River. The importance of this inland waterway is also pointed out by its contribution to China's gross domestic product (GDP) which was 35 % in 2010. 80% of China's total inland cargo shipping is related to the Yangtze river. The most important ports are located at Chongqing, Wuhan, Shanghai and Nanjing.²⁷

The port of Chongqing is the biggest inland port of the Yangtze River with 1.1 billion tons of cargo handled in 2012. In addition, three million TEUs are passing the Chongqing annually. In Chongqing, inland navigation is very important which is also shown by the annual growth rate of waterway transport (+ 16.8%). Due to its strategic location, Chongqing serves as a logistical gateway to connect Western China with the rest of the country as well as international destinations. In fact, 90 % of the products manufactured in Chongqing and destined for export are transported via the Yangtze River. The main advantage of this port is that it provides a multimodal infrastructure. Cargo can be transhipped in the port and can be further transported by the transport modes rail, road or air. To stay competitive, Chongqing continues to invest in the development of the infrastructure.²⁸

2.3. Inland navigation in Brazil

Brazil has the most available inland waterways in South America (50,000 km).²⁹ Compared to other transport modes, the broad Brazilian river system covers almost all territorial extensions. This leads to lower transport costs compared to rail and road on short transport distances. Nevertheless, only 22% of Brazilian inland waterways are used for freight transport. This is partly due to the fact that the main rivers are not located at the centres of production and consumption. In addition, compared to China and Europe, few investments are made in the inland waterway infrastructure. As a consequence, inland navigation makes a small contribution to the Brazilian economy.³⁰ Goods, which are mainly transported on the inland waterways in Brazil, are agricultural and mineral goods.

Currently about 45 million tons of goods are transported on inland waterways in Brazil. Nevertheless, the potential transport volume of inland waterways in Brazil could reach 180 million tons per year.³¹ There are three main inland waterway traffic routes: the Amazonas, the Sao Francisco and the Tocantins-Araguaia.³² Even though inland waterways are not frequently used as transport modes in

²⁶ URL: <http://www.wwinn.org/china-inland-waterways> [29.07.2016]

²⁷ Cf. Rivers of the World, 2010, p.55ff and PIANC, 2009, p. 23

²⁸ Cf. Consulate General of the Kingdom of the Netherlands in Chongqing/ Netherlands Business Support Office in Chengdu, Sichuan, 2014, p. 3f and Cf. Rivers of the World, 2010, p. 55ff

²⁹ URL: <http://www.indexmundi.com/map/?t=10&v=116&r=as&l=en> [29.07.2016]

³⁰ Cf. Rivers of the World, 2010, p. 47

³¹ URL: <http://www.wwinn.org/brazil-inland-waterways> [29.07.2016]

³² Cf. Rivers of the World, 2010, p. 45

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Brazil, ports are of international importance - ports participated in about 90 % of the country's export and import trade in 2010.³³

The **Amazonas** has a length of 6,280 km and is the longest river in the world.³⁴ The route runs from Peru through northern Brazil to the Atlantic Ocean.³⁵ The banks of the Amazonas mostly consist of a tropical rainforest. This leads to the threat of theft – in fact, 27 million dollars were lost in the Amazonas region in 2015 due to thefts.³⁶

The port of Manaus is the main transport hub for transports on the upper part of the Amazon Basin. The cargo volume per year is 11.8 million tons. In 2007, the total trade volume of the port of Manaus was 4.92 billion US dollar, whereas exports accounted for 1.15 billion US dollars.³⁷

Fruits, seeds, machinery, wood and fuels are products which were mainly loaded in the port of Manaus. Machinery and electrical goods are mainly imported due to the Manaus' industrial tax free zone. In this zone companies, in particular in the electrical and electronic sector, enjoy federal tax breaks.³⁸

2.4. Comparison

As can be seen in the table below, the numbers significantly differ for Europe, China and Brazil: China has the most available waterways, the highest transported volume on waterways and the highest volume handled in ports compared to Europe and Brazil. Even though Brazil has more available waterways than Europe, around 12 times more volume is transported on European inland waterways.

These differences can be seen in context with the importance of inland navigation in the different countries/regions. In Europe and China, inland waterways are seen as important transport modes and various measures are used to increase the use of inland waterways. Besides financial support, promotional actions can be named as examples of such measures. In this context, investments in the waterway infrastructure can be seen as a main measure to guarantee the competitiveness of inland navigation.

³³ Cf. Martins, et al., 2013, p.1

³⁴ URL: <http://www.winn.org/brazil-inland-waterways> [29.07.2016] and Rivers of the World, 2010, p. 41

³⁵ URL: <http://www.thefreedictionary.com/Transport+on+the+Amazon> [29.07.2016]

³⁶ URL: http://www.joc.com/trucking-logistics/cargo-thefts-rise-brazil-economy-shrinks_20150903.html [16.07.2016]

³⁷ Cf. Ministry of External Relations, 2008, p. 11

³⁸ URL: http://www.worldportsource.com/ports/review/BRA_Port_of_Manauas_3506.php [29.07.2016] and http://www.joc.com/port-news/south-american-ports/container-terminals-jungle-city-manaus-face-growing-pains_20150702.html [16.07.2016]

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	Europe	China	Brazil
Available waterways	40,000 km	123,495 km	50,000 km
Important waterway in region	Rhine-Main-Danube Corridor	Yangtze-River	Amazon
Transported volume on waterways in total	551 million tons	1,180 million tons	45 million tons
Transported goods	dry & bulk cargo, construction material	dry & bulk cargo, construction material	mainly agricultural and mineral goods
Important inland ports in region	Duisport	Chongqing	Manaus
Volume handled in ports	131 million tons	1.1 billion tons	11.8 million tons
Importance of inland navigation in region (political/economical)	High	High	Low
Share of inland navigation in Modal Split	7 % (2013)	24 % (2012)	14 % (2008)

Table 1- Comparison of inland navigation in Europe, China and Brazil (source: own illustration)

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3. Factors influencing the competitiveness of inland navigation

The main competitive factors of inland navigation in terms of infrastructure are: fairway depth, bridges, maintenance and ports.

3.1. Fairway depth

“The fairway or fairway channel is the area of a body of inland water for which certain fairway depths and fairway widths are maintained for navigation purposes. The width and the course of the fairway are marked by internationally standardised fairway signs such as buoys or marks on river banks.”³⁹

The fairway depth is critical for the transport on a waterway because the possible freight volume of a vessel depends on the fairway depth. Water depths available in the fairway determine how many tons of goods may be carried on an inland cargo vessel. The more cargo loaded on board of a vessel, the higher is its draught loaded, i.e. the draught of a ship when stationary and when carrying a certain load. The draughts loaded which may be realised by navigation companies have a decisive influence on the cost-effectiveness of inland waterway transport.

Different factors influence the Fairway depth (see Figure 5):⁴⁰

- Under keel clearance (=safety clearance to riverbed)
- Squat (= when the ship sink when they are in motion, depends on cross sections)
- Cross section of fairway (depth and width) base on minimal cross section
- Maintenance of the fairway

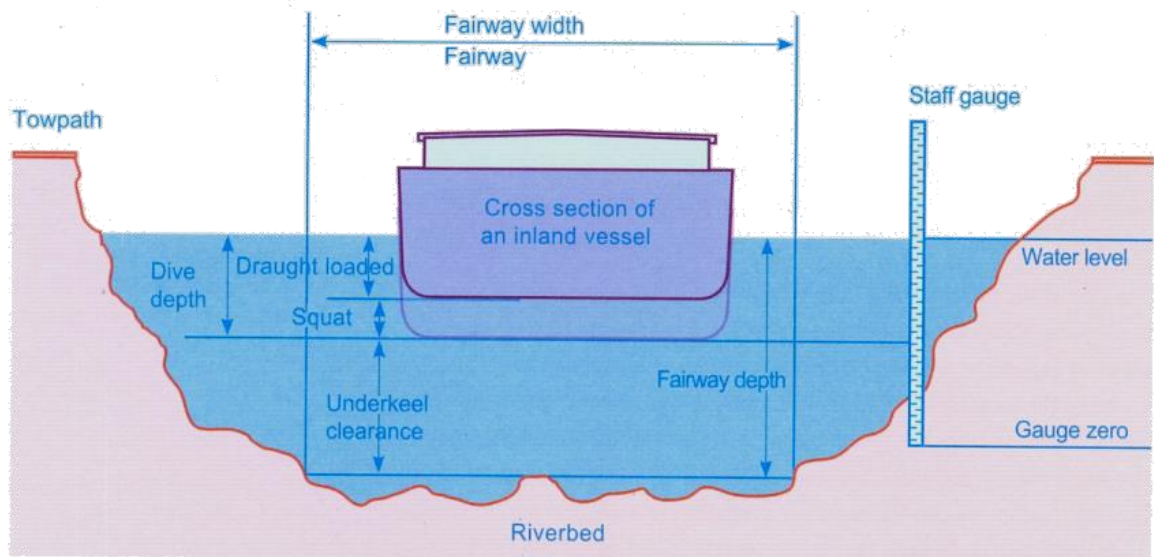


Figure 5 - Fairway geometrical dimensions (Source: viadonau)

³⁹ Cf. Dolinsek, et al., 2013, p.51

⁴⁰ Cf. Dolinsek, et al., 2013, p.51ff

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3.2. Bridges⁴¹

- Can span a waterway or a lock facility (port entrance, river power plant)
- Influence the cost-effectiveness of inland waterway transport
- Passage of vessel depends on:
 - bridge clearance
 - highest fixed point of the vessel (HNWL – highest navigable water level)
 - water level influencing the fairway width (LNWL – lowest navigable water level) → by pumping water into ballast tanks of vessel air draught and highest fixed point can be reduced
 - distance between bridge pillars

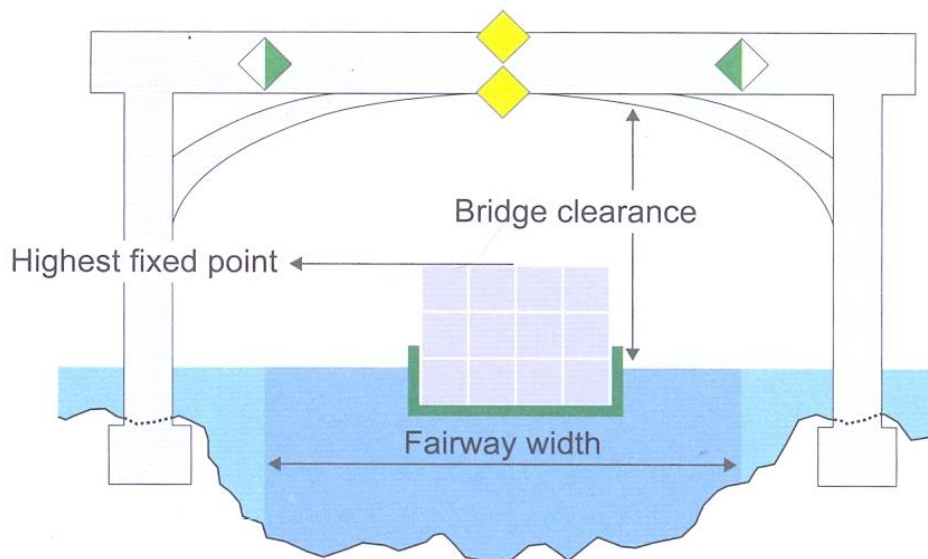


Figure 6 - Air draught of a vessel and vertical bridge clearance as determining parameters for passages under bridges (Source: viadonau)

3.3. Maintenance⁴²

Maintenance is important to guarantee a competitive waterway infrastructure. Waterways, as living systems, are influenced by constant changes and therefore monitoring is required to guarantee navigability. Therefore, it is necessary to establish a “fairway maintenance cycle” which includes necessary measures.

The necessary works for the maintenance of the fairway on natural waterways depend on the general characteristics of the respective river: in free-flowing sections the flow velocity of the river is higher than in impounded sections, in artificial canals or in sections flowing through lakes. In free-flowing sections of

⁴¹ Cf. Dolinsek, et al., 2013, p.57ff

⁴² Cf. Dolinsek, et al., 2013, p.61ff

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rivers the transport of sediments is an important dynamic process, especially in periods with higher water levels and the corresponding higher flow velocities of the river. In the case that the minimum fairway parameters are not achieved, the responsible waterway administration is obliged to take suitable measures in order to re-establish them. Such maintenance is cyclic and consists of 4 steps: monitoring, planning, execution and information. The 4 steps of the maintenance cycle and the main tasks within each step are shown in Figure 7.

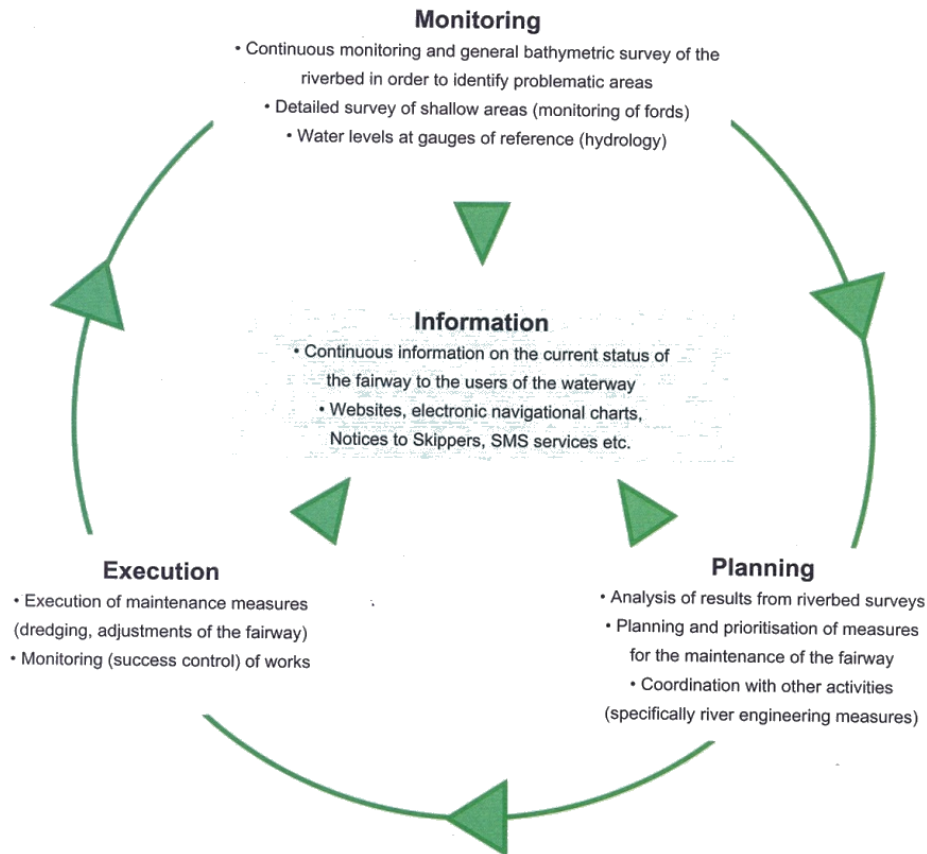


Figure 7 - The "fairway maintenance cycle" (Source: viadonau)

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3.4. Ports

Every port is structured into three main areas:

- Water-side area
- Port area
- Hinterland

The water-side area of a port is formed by a port basin and quay walls. The lengths of the quays are divided into multiple berths. The port area includes the loading area, which is located just behind the quay walls. This area has cranes, crane tracks and quay rails. The hinterland is the neighbouring area of a port. From the hinterland the traffic flows and it is concentrated into the port.⁴³



Figure 8 - Basic structure of a port (Source: viadonau, EHG Ennshafen GmbH)

“According to the World Bank, ports can be divided into four categories:

- public service ports
- tool ports
- landlord ports
- private service ports

In public service ports the port authority provides all the services relevant for the functioning of the port system. The port owns and operates all available fixed and mobile facilities and maintains them. Port transshipment is performed by personnel who are directly employed by the port authority. The main functions of a public service port include cargo transshipment activities.

Tool ports are primarily of a public nature. In this model the port infrastructure and the port superstructure are owned by the port authorities. The authority is also responsible for their further development and maintenance.

Landlord ports are predominant in large and medium to large sized ports. While the port authority has the role of a public regulator and properly owner, private companies carry out the port operation. The

⁴³ Cf. Dolinsek, et al., 2013, p.79ff

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infrastructure is mainly leased by private companies. Private transshipment companies provide the superstructure, including the buildings and maintain them.

Fully privatized ports are rarely located along the Danube. The State does not intervene in the development or operation of the port. Public interest is only preserved at a higher level, such as building regulations or regional traffic planning. Land and property are both privately owned and the ports are self-regulating. Legal regulations applying to ports and its users, vehicles and floating objects are embodied in the Austrian Navigation Act. The law includes the port fees for the public ports. The Regulation for Shipping Facilities regulates the arrangement, operation and use of shipping facilities. This also includes regulations for other facilities built on the waterways as floating buildings, floating restaurants, hotels.”⁴⁴

“Based on the different characteristics of the transported goods a port must offer many different types of storage facilities in order to prevent damage to cargo. Depending on the intended purpose, there are two different types of warehouses: storage warehouses and distribution warehouses. With regards to type of construction, there are open storage facilities, covered storage facilities and special-purpose storage facilities. Open storage is the place where non-sensitive goods are stored. These goods have a comparatively low value and they are not affected by rain or fluctuation of the air temperature. Covered storage is a facility where the goods are partly protected from adverse weather conditions and high value goods can be safely stored. Special storage can be silos, tanks, bulk goods storage facilities, refrigerated storage or freezer storage.”⁴⁵ Examples for types of goods stored in the different types of storage facilities are shown in Figure 9.

Types of storage facilities			
Construction	Open	Covered	Special warehouse
Examples	Open storage in ports, container depots	Special warehouse for oversized goods, warehouse for general cargo	Grain silos, liquid cargo tanks, dangerous goods and cold storage
Types of goods	Coal, ore, containers, gravel etc.	General cargo on pallets, carton packed goods, paper rolls etc.	Grain, soya, gasoline, oil, liquid gas, chemicals etc.

Figure 9 - Overview types of storage (Source: viadonau)

“Ports connect the transport modes of road, rail and waterway and are important service providers in the fields of transshipment, storage and logistics. In addition to their basic functions of transshipment and storage of goods, they also often perform a variety of value added logistics services to customers such as

⁴⁴ Cf. Dolinsek, et al., 2013, p.90ff

⁴⁵ Cf. Dolinsek, et al., 2013, p.87ff

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packaging, container stuffing and stripping, sanitation and quality checks. This enhances ports as logistics platforms and impetus sources for locating companies and boosting the economy. As multimodal logistics hub, they act as a central interface between the various modes of transport. The total throughput for all modes of transport is an important indicator of the performance of the port. A port not only handles transshipments between waterway, road and rail, but also between non-water bound modes such as road-rail or rail-rail.”⁴⁶

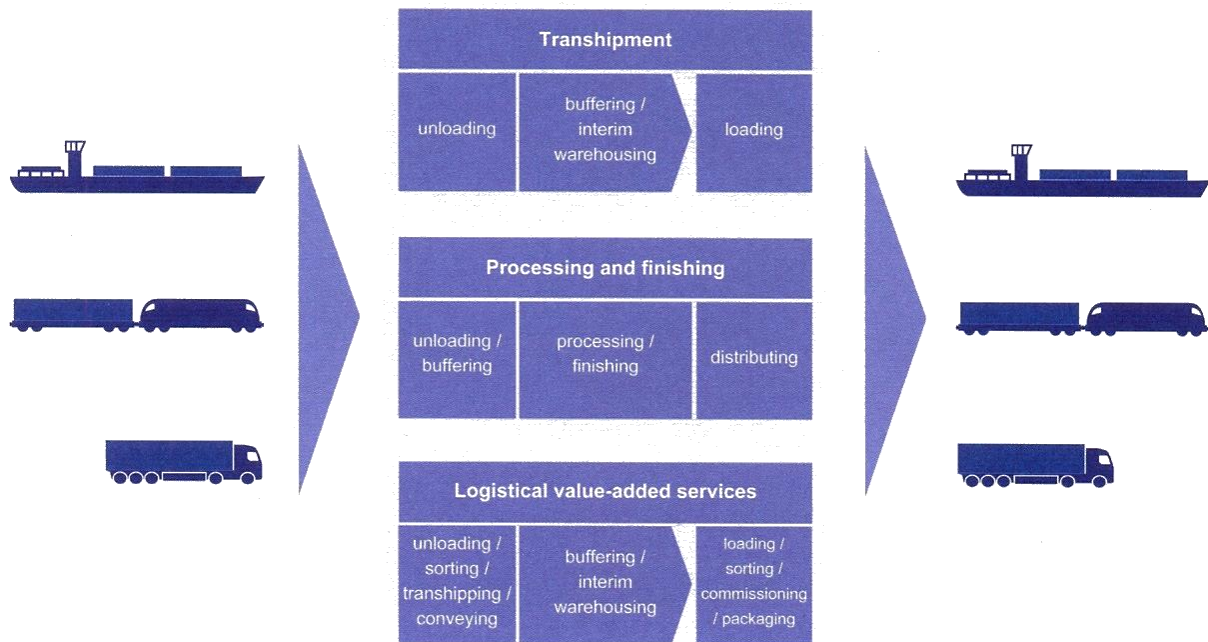


Figure 10 - The inland port as a multimodal logistics node (Source: viadonau)

3.5. Information Services

River information Services (RIS) is a service to assist the shipping of freight and passengers. The service is offered to increase the traffic safety and to improve the efficiency, reliability and scheduling of transport.⁴⁷ “Inland ENC’s are electronic navigational charts which can be displayed with the aid of special software (Inland ECDIS). The basic contents of electronic inland navigation charts (Inland ENC’s) include:

- Limits of the fairway
- Traffic control data
- Structures and obstacles
- Shorelines and river engineering structures
- Orientation guidance”⁴⁸

⁴⁶ Cf. Dolinsek, et al., 2013, p.78f

⁴⁷ Cf. Dolinsek, et al., 2013, p.124

⁴⁸ Cf. Dolinsek, et al., 2013, p.126

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“Notices to skippers (NtS) support traffic safety on inland waterways. In a similar way to traffic reports for road transport, NtS are published by the competent authorities and contain information regarding the usability of the transport infrastructure. Among the fundamental functions of NtS are:

- Fairway and traffic related messages with information about waterway sections or objects (locks or bridges) such as suspension of navigation, reduced passage heights, widths or depth
- Water level related information, with information about water levels, lowest fairway depths according to riverbed surveying, vertical clearance under bridges and overhead cables, flow regime or water level forecasts
- Ice messages containing information about obstructions and suspension of navigation caused by ice”⁴⁹

Electronic Reporting (ERI) of dangerous goods is a report required by different authorities from the shipping companies which are involved in transportation of dangerous goods.⁵⁰ “River Information Services supported by Electronic Reporting include:

- Strategic traffic information
- Locks and bridge management
- Avoidance of accidents
- Transport management
- Border control and customs services”⁵¹

⁴⁹ Cf. Dolinsek, et al., 2013, p.127

⁵⁰ Cf. Dolinsek, et al., 2013, p.128

⁵¹ Cf. Dolinsek, et al., 2013, p.129

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3.6. Weather Conditions

Seasonal influences of the weather are very important when a transport mode is selected. There are different weather phenomena with high and low influence under the navigation performance. All of them mainly influence the water level. In Figure 11 the influences of the level of water on the ship speed is presented. For a constant delivered power, for instance 800 kW, the ship speed will be lower if the ship sails in low water.

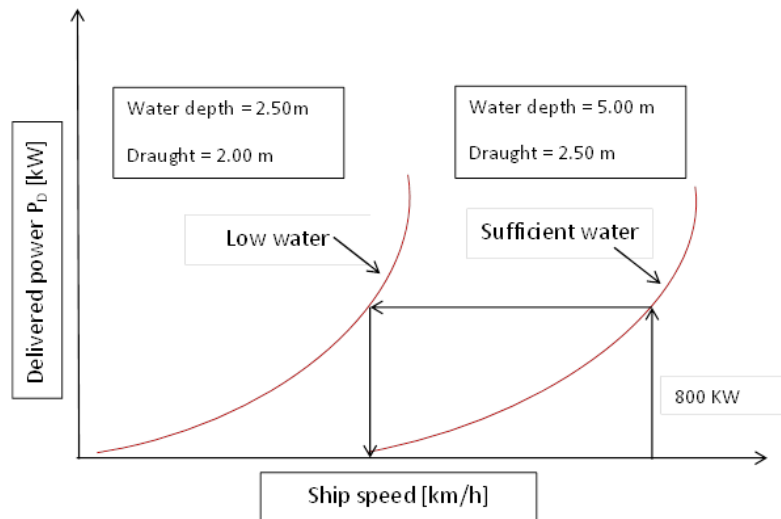


Figure 11- Delivered power depending on ship speed on low and sufficient water (own illustration, based on Schweighofer, 2012, p.5)

Phenomena with high influence:⁵²

Low waters: The travel time is influenced by the level of the water through the changes of the weather. The dry season is characterized by a low level of water. The speed of the ship will be changed in order to be in accordance with the level of water and that will conduct to a higher consumption of the fuel.

High waters: In high water conditions, the river morphology is changing and sometimes the navigation can be suspended due to:

- aggradations (the deposition of material by a river, stream, or current on its own bed and on the sides)
- damage of towpaths
- Damage of banks and flood protection installations

⁵² Cf. Schweighofer, 2013, p. 25ff

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Phenomena with low influence⁵³

Ice on water:

- Possible damage of navigation signs and installations on banks
- Sometimes, suspension of the navigation is required
- The ship /convoy are navigating with lower speed , due to the risks of impacts and/or damaging of the hull → delays of the estimated time of arrival

Windy weather: When the weather is windy and storms are acting there are necessary increased requirements on manoeuvrability and course stability. Such weather conditions cause accidents due to environmental reasons.

Reduced visibility

- Caused by fog, rainfall, haze, snowfall or other
- it is necessary to reduce the speed or to interrupt the navigation
- The skippers will navigate using radar

⁵³ Cf. Schweighofer, 2013, p. 27ff

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Figure 12 - Accident caused by the low level of water in summer (Source: IMST)



Figure 13 - Accident caused by the high level of water after flood (Source: IMST)



Figure 14 - Presence of ice in locks under the navigation conditions (Source: via Donau)



Figure 15 - Barge hull broke by ice in winter season (Source: IMST)

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