Overview Vessel Types on the Danube

1. Introduction

This document describes the most important vessel types for Danube IWT.

In the first part of the document, various vessel types and their load capacities and cargo hold measurements are given. Furthermore, advantages and disadvantages of the different cargo vessels in terms of manoeuvrability, behaviour in different traffic situations and environmental conditions are pointed out.

In the second part of the document information on environmental advantages of IWT is presented and the importance of nautical information for Danube logistics is elaborated.

2. Ships Types and their characteristics

There are principally two different means of transportation on inland waterways: by self-propelled ship and by barges pushed by a self-propelled vessel (push boat or pushing cargo ship).

Inland vessels are classified according to their size and purpose. The target group here are cargo vessels and these can be further distinguished by the kind of commodity, most generally into dry-cargo ships and tankers.

On the Danube River there are various ship types for different cargo categories and volumes. In this section, the main ship types and their sizes as well as their advantages in terms of manoeuvrability, in different traffic situation and environmental conditions and their environmental friendliness are described.

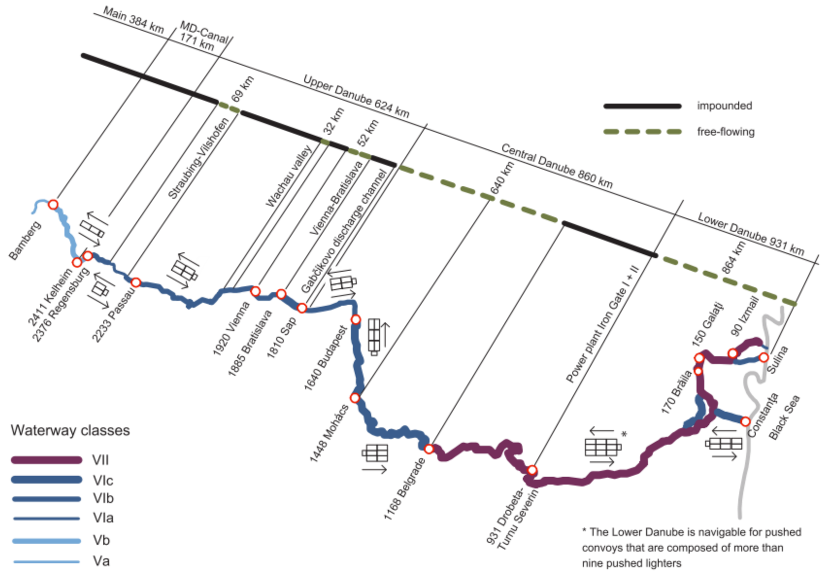


Figure 1: Waterway classes for the Danube

In Europe, waterways are divided into the so-called CEMT classes. This classification is determined by the *Conférence Européenne des Ministres de Transport* (European Conference of Ministers of Transport), hence the term CEMT class. Each class gives the maximum size of a vessel that is suited for a certain waterway. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows the waterway classes along the Danube.

2.1 Motor Cargo Vessel

In general, the Motor Cargo Vessel is a single-hull ship type suitable for various types of cargo: Liquids, bulk products, containers or special cargo. In terms of manoeuvrability this ship type is best compared to any formations with numerous barges which are slow in reaction to change of course. Therefore the motor cargo vessel can also be handled navigated easily in difficult traffic or environmental conditions.

There is a wide variety in sizes: For self-propelled cargo ships it varies from a small 38-40 m long “peniche” having a cargo capacity of only about 300 t at 2.5 m draught to a large 135m long and up to 17m wide river ship with on average about 3500 t capacity at the same draught.

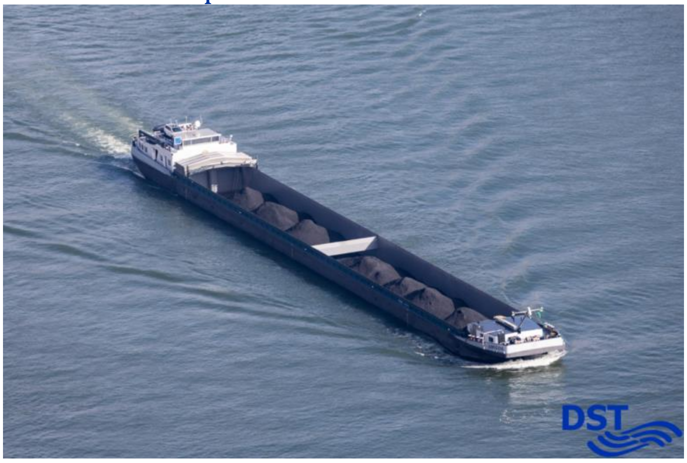


Figure 2 Bulk carrier: CMS Amigos, L: 135 m – B: 11.45 m – D: 3.60 m – T: 3922 t – P: 2x1020kW + 290kW bow thruster

Figure 3 Container ship: GMS Nova, L: 134,16m – B: 16,90m – D: 3,52m – T: 5175t – P: 2 x 1100kW + 860kW and 400kW bow thrusters

Figure 4 Tank vessel: TMS Tim, L: 110 m - B: 11,45 m - D: 3,61 m - Ton: 2991 t – P: 1100kW + 400kW bow thruster

Figure 5 RoRo ship for cars: RoRo TERRA - L: 110 m - B: 12 m - D: 2,16 m - T: 710 t – P: 2 x 750kW + 240kW bow thruster

Below some characteristics of typical motor cargo vessel types are given. The maximum velocity of an inland waterway vessel rises with the water depth. Therefore, each table provides two different water depths and their corresponding velocities.

Table 1 Johann Welker Type (CEMT Class **IV**)

Max. Length [m]	85	
Breadth [m]	9,5	
Draught [m]	2,5	
Cargo load [t] / [TEU]	1350 / 60	
Water depth [m]	3	5
Velocity [km/h]	15	18
Power Installed [kW]	approx. 750	

Table 2 Large Rhine Vessel (CEMT Class **Va**)

Max. Length [m]	110	
Breadth [m]	11,4	
Draught [m]	3,0	
Cargo load [t] / [TEU]	2750 / 200	
Water depth [m]	3	5
Velocity [km/h]	15	18
Power Installed [kW]	approx. 2000	

Table 3 Large Rhine Vessel (CEMT Class **Vb**)

Max. Length [m]	135	
Breadth [m]	11,4	
Draught [m]	3,5	
Cargo load [t] / [TEU]	4000 / 500	
Water depth [m]	3	5
Velocity [km/h]	15	18
Power Installed [kW]	approx. 2000	

2.2 Pushed Convoys

Pushed convoys usually consist of 2, 4 or 6 barges operated by a push boat of appropriate power. Standard European barges (see Table 4) in common use in large number on the entire Rhine-Main-Danube corridor have a length of 76.5 m, a beam of 11.0 or 11.4 m and a carrying capacity of about 1650 t at 2.5 m draught. The large 6-barges convoy has a length of up to about 270 m (push boat and three barges in length, two side-by-side). When running downstream the river barges are usually arranged two in length, three abreast and in this case the train has an overall breadth of up to 34.35 m (Figure 6).

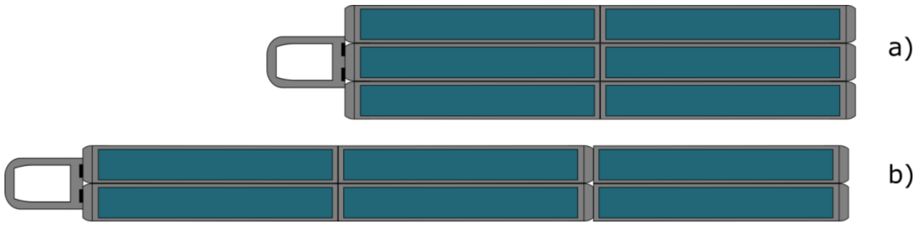


Figure 6: Convoy with 6 barges in upstream a) and downstream b) formation

Typical cargo types for barges are bulk products. But also liquids, containers and general cargo are suitable. A pushed convoy is the most flexible transport option. It allows the simultaneous transport of different cargo types as each barge in the formation may load different cargo. In addition, barges may be replaced by others at each port called or have different destinations during a single voyage.

Figure 7 Pushed Convoy PB+1: PB SWIND, L: 15.00 m – B: 9.50 m – D: 1.90 m – P: approx. 2x 500kW; Barge CHEMGAS 21, L: 76.52 m – B: 11.43 m – D: 2,75 m – T: 1467 t

Figure 8: Pushed convoy PB+1+1: HERKULES IX, L: 32.00 m – B: 11.40 m – D: 1.85 m – max. pushed weight: 12,000t, P: 2 x 1120kW; 2 Barges à 76.5m x 11.45m

Figure 9: Pushed convoy PB+2+2: HERKULES VIII, L: 39.88m – B: 11.38 m – D: 1.70m, P: 2 x 2200kW; 4 Barges à 76.5m x 11.45m

Various barge sizes exist within inland navigation. The most common are described below. The different bow shapes can be seen in Figure 10 and Figure 11. The wedge frame bow for example was developed to optimize the flow conditions of the push boat behind the barges.

Table 4 Most common barge sizes

	Europa 1	Europa 2	Europa 2a	Europa 2b	Europa 2c
Length [m]	70	76.5	76.5	76.5	76.5
Breadth [m]	9.5	11.2, 11.4, 11.45	11.45	11.45	11.45
Draught [m]	2.5	2.5	4.0	4.0	4.0
Bow shape	Ponton	Ponton	Ponton	Wedge frame	Reshaped wedge frame
Weight [t]	270	370	400	415	415
Cargo Hold					
Top length [m]	60.3	66.9	66.3	66.3	66.3
Bottom length [m]	58.5	65.1	62.7	62.7	62.7
Top breadth [m]	7.5	9.0	9.0	9.0	9.0
Bottom breadth [m]	7.5	9.0	9.0	9.0	9.0
Height [m]	3.8	3.7	4.2	4.2	4.2
Max. volume [m^3]	1640	2178	2437	2437	2437
Max. cargo at D_{max} [t]	1700	2215 - 2240	2565	2619	2619
Max. TEU, 4 layers	108	120	120	120	120
Max. TEU, 4 layers *	144	160	160	160	160
Power Installed [kW]	No power installed				

* A barged that is optmized for container transport, can store 4 containers over its width

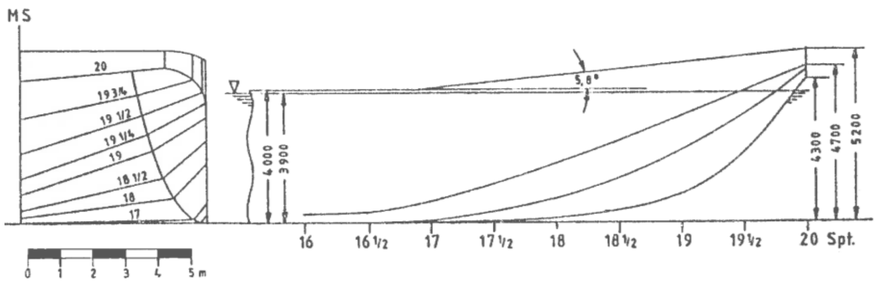


Figure 10 Wedge frame bow

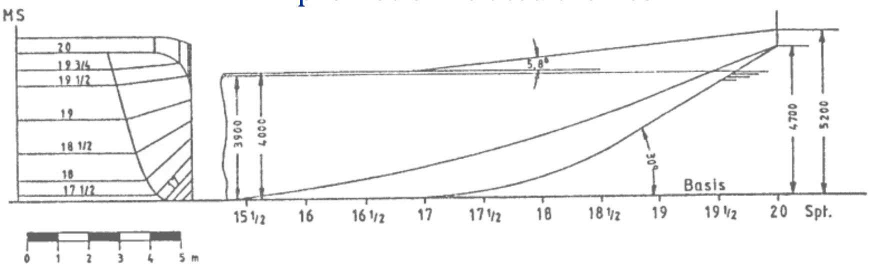


Figure 11 Ponton bow

Table 5 Pushed convoy PB + 1 + 1 or PB + 2 (CEMT Class **VIa**)

Max. Length [m]	172	
Breadth [m]	11,4	
Max. Draught [m]	4,0	
Max. Cargo load [t]	5500	
Water depth [m]	3	5
Max. Velocity [km/h]	12	14
Power Installed [kW]	approx. 2800	

Table 6 Pushed convoy PB + 2 + 2 or PB + 1 + 1 (CEMT Class **VIb**)

Max. Length [m]	193	
Max. Breadth [m]	22,9	
Max. Draught [m]	4,0	
Max. Cargo load [t]	11000	
Water depth [m]	3	5
Max. Velocity [km/h]	12	14
Power Installed [kW]	approx. 3400	

Table 7 Pushed convoy PB + 2 + 2 + 2 or PB + 3 + 3 (CEMT Class **VIc**)

Max. Length [m]	270	
Max. Breadth [m]	34,2	
Max. Draught [m]	4,0	
Max. Cargo load [t]	16500	
Water depth [m]	3	5
Max. Velocity [km/h]	11	13
Power Installed [kW]	approx. 4500	

2.3 Coupled formation

A coupled formation consists of one motor cargo vessel and a barge. Often the barge's aft is fitted adapted to the ship's bow shape. The barge in front is equipped with a pump jet of approximately 500kW to assist manoeuvring.

Table 8 Coupled formation Ship + 1 (CEMT Class **VIb**)

Max. Length [m]	185	
Breadth [m]	11,4	
Max. Draught [m]	3,5	
Max. Cargo load [t] / [TEU]	6000	
Water depth [m]	3	5
Max. Velocity [km/h]	12	14
Power Installed [kW]	approx. 2000	

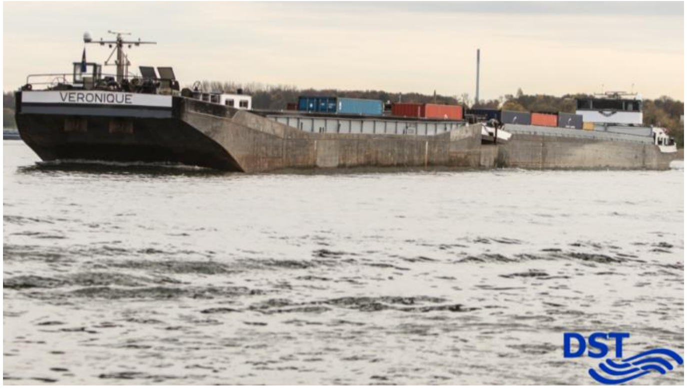


Figure 12 Coupled Formation: GMS Veronique, L: 110.00 m – B: 11.45 m – D: 3.32 m – T: 3066 t / 208 TEU – P: 2 x 970 kW + 300kW bow thruster; Barge VERONIQUE II, L: 71.00 m – B: 11.45 m – P: approx. 560 kW + 240 kW bow thruster

2.4 Special Cargo Transport

There are various vessel types available for special transport of heavy or voluminous cargo. One aspect that needs to be kept in mind for such a transport is the heights of the bridges to be passed.

Single heavy or voluminous units can be put on pontoon barges (see Figure 14). It is also possible to put the units in a bulk carrier (e.g. wire coils, slabs).

Figure 13 Motor vessel for special heavy or voluminous cargo: Roro BREUIL, L: 75.0 m – B: 13.8 m – T: 1300t. The BREUIL carries the wings for the Airbus A380.

Figure 14 Pushed convoy for special cargo: Pushboat Broedertrouw 2, L: 19.4m – B: 10.3m – D: 1.6m – T: 96t; Barge Lastendrager 12, L: 66.4m – B: 11.4m – T: 1439t; Barge Lastendrager 22, L: 36.5m – B: 6.9m – T: 272t; Barge Lastendrager 22, L: 40.8m – B: 7.8m – T: 351t). The convoy transported the spacecraft Buran on the Rhine to a museum in Speyer, Germany.

2.5 Manoeuvrability

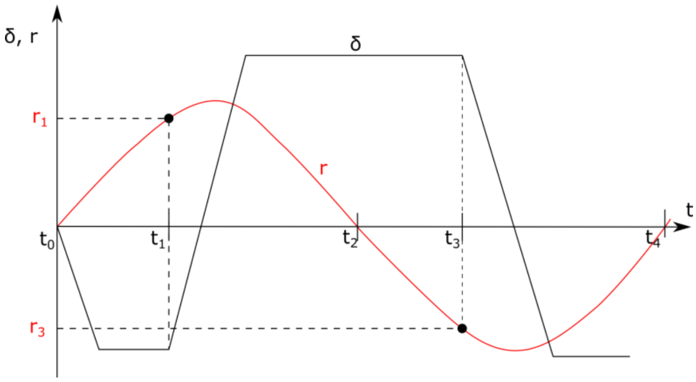
In comparison with the navigation in spacious and deep sea stretches the ship running on inland waterways meets certain specific restrictions. These restrictions characterised by shallow water or a narrow waterway or - simultaneously and in most usual case – both have a large impact on technical performances and consequently on economic effects of inland vessels.

The *Inland Water Vessel Inspection Regulations* [1] regulates the manoeuvrability of inland waterway ships. The following numbers and figures describe the manoeuvring abilities of different ship types. In general it can be said, that the larger the ship or formation and the more coupling points a formation has, the slower the manoeuvers. The fastest manoeuvres can therefore be done with a single motor vessel. The following table shows requirements for the evasive action manoeuvre and the turning manoeuvre for different ships and formations. The water depth is described by *h*; *T* is the ship's draught. *δ* is the rudder angle.

Table 9 Time limits for manoeuvres dependant on ship or formation size. Taken from [1]

Ship- or formation size in metres	Required turning velocity $r_1 = r_3$		Required limits for time t_4 in seconds in shallow and deep water		
	δ = 20°	δ = 45°	1.2 ≤ h/T ≤ 1.4	1.2 ≤ h/T ≤ 2	h/T > 2
All motor vessels or single-lane vessel ≤ 110 x 11.45	20°/min	28°/min	150 s	110 s	110 s
Single-lane formations ≤ 193 x 11.45 or two-lane formations ≤ 110 x 22.90	12°/min	18°/min	180 s	130 s	110 s
Two-lane formations ≤ 193 x 22.90	8°/min	12°/min	180 s	130 s	110 s
Two-lane formations ≤ 270 x 22.90	6°/min	8°/min	(*)	(*)	(*)
(*) data specified by nautical surveyor					

In the following Figure 15 the manoeuvre can be seen.



t_0	Begin of manoeuvre
t_1	Time reaching turning velocity r_1
t_2	Time reaching turning velocity r_2 =0
t_3	Time reaching turning velocity r_3
t_4	Time reaching turning velocity r_4 =0 End of manoeuvre
δ	Rudder angle [°]
r	Turning velocity [°/min]

Figure 15 Avoidance and Turning Manoeuvre [1].

3. Environmental friendliness

Various studies outline that the inland waterway vessel is the most environmental friendly transport mode compared to others like truck and train.

Various studies outline that the transport system Inland waterway vessel / inland waterway is environmental friendly, cost-effective and safe.

Inland waterway vessels are spacious, have a favourable payload to deadweight relation, induce comparatively low personal costs and need a relative small amount of energy for transport.

Even though the transport network for inland navigation is more wide-meshed than for other transport modes, the importance of inland waterway should not be underestimated: about 25% of the total hinterland transport performance is done by inland waterway vessels.

As described above, the inland waterway vessel requires the smallest amount of energy for transport compared to other modes. This also means that its proportion of total freight transport emissions is small.

The noise emitted by inland waterway vessels is so low, that no noise protection measures need to be taken along inland waterways. Inland waterway vessels contribute with minor impact on water pollution. Contaminations due to accidents are seldom; the traffic safety is high. [2]

The following Figure 16 contains some data on the emissions from the three transport modes.

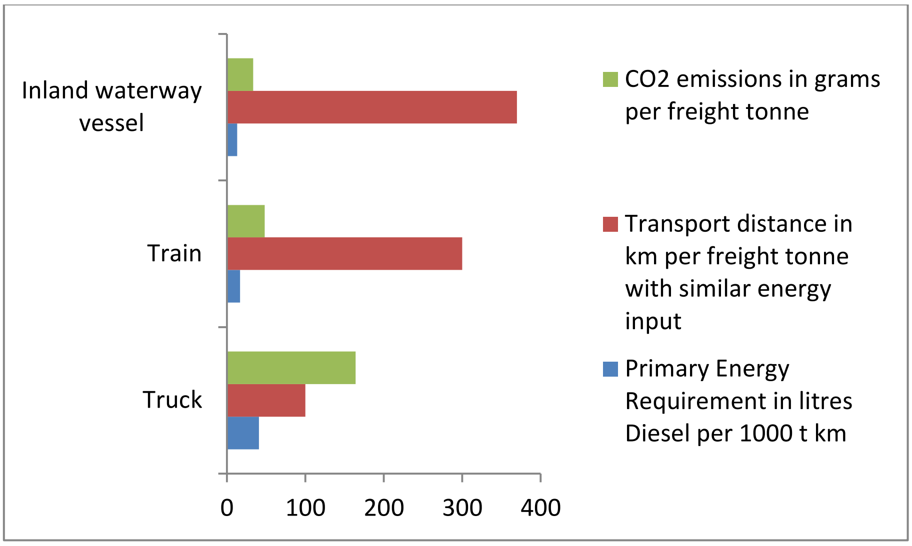


Figure 16 Data on emissions and fuel consumption of different transport modes. Taken from [2].

4. Importance of nautical information for Danube logistics

To ensure a safe and in-time transport on the Danube various information is needed.

4.1 Water levels

Before starting the journey, the skipper collects information on the current and predicted water levels on the stretch. Depending on the route length, data for 8 to 10 day in advance is required. This also includes the fairway conditions in relation to water levels and their change over time. A hydraulic model based on long-term measurements generates these data. Particularly, narrow passages are dependent on the water level and need precise predictions.

In times of very shallow water conditions on the Danube, e.g. in a dry summer, vessels will have a lower load capacity due to smaller draught. This means that for a certain amount of cargo more ships may be needed.

4.2 Infrastructure

Knowledge on harbour infrastructure such as quay length, mooring sites, cranes or terminals is essential for the journey to ensure that the freight can be unloaded at the port of destination. Also the operating times of locks or bridges are decisive.

4.3 Narrow passages and size limits

Dependant on the waterway class, there is a limit in ship size for e.g. the upper Danube. Also bridge heights shall be taken into account. Low bridges may limit the number container layers that can be stowed. Moreover the sizes of lock chambers need to be known. Sometimes a formation does not fit in one piece inside so that it needs to pass the lock in several parts. The longer travel time should be taken into account in journey planning.

5. Literature

[1] Verordnung über die Schiffssicherheit in der Binnenschifffahrt, Binnenschiffsuntersuchungsordnung – BinSchUO, (*Inland Water Vessel Inspection Regulations*), December 2008

[2] Wasser- und Schifffahrtsverwaltung des Bundes (WSV), Binnenschiff und Umwelt, https://www.wsv.de/Schifffahrt/Binnenschiff_und_Umwelt/, April 2017

Project website: www.interreg-danube.eu/danube-skills