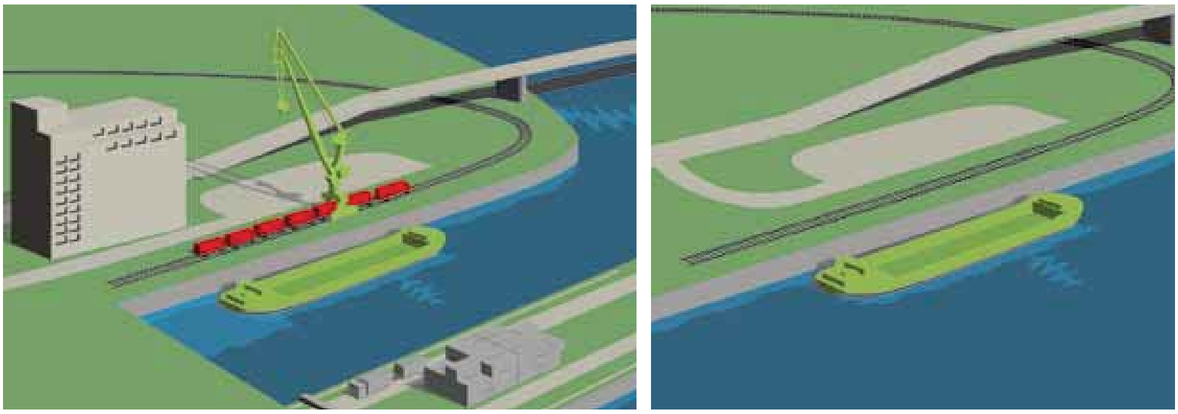
READER – PORTS AND INLAND VESSELS

Extract of relevant passages from the „Manual of Danube Navigation”, via donau (2012) and the „Annual Report 2014“ from via donau

Terminology

Ports are facilities for the transhipment of goods that have at least one port basin. Transhipment points without a port basin are known as **transhipment sites**.



Source: via donau

Comparison of ports and transhipment sites

In comparison to a transhipment site, a port has multiple advantages: on one hand, it has longer quay walls and can therefore offer more possibilities for transhipment and logistics. Certain cargoes are only allowed to be transhipped in a port basin in accordance with national laws. Additionally, the port provides an important protective function: During flood water, ice formation or other extreme weather events ships can stay safe in the port.

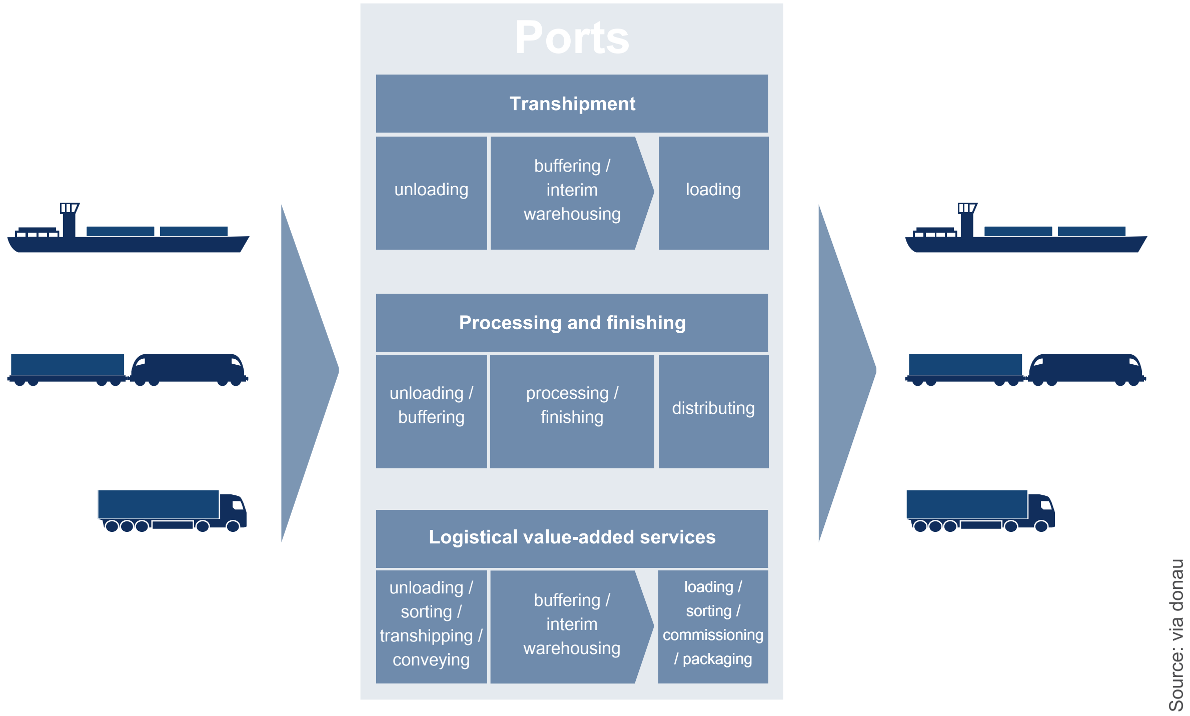
A **terminal** is a facility of limited spatial extension for the transhipment, storage and logistics of a specific type of cargo (e.g. container terminal or high & heavy terminal). A port or a transhipment site may dispose of one or more terminals.

Ports as logistical service providers

Functions and performance of a port

Ports connect the transport modes of road, rail and waterway and are important service providers in the fields of **transhipment**, **storage** and **logistics**.

In addition to their basic functions of **transhipment** and **storage** of goods, they also often perform a variety of value-added logistics services to customers, such as **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 hubs, they act as a central interface between the various modes of transport.



The inland port as a multimodal logistics node

The total throughput for all modes of transport is an important indicator of the **performance** of a port. A port not only handles transhipments between waterway, road and rail, but also between non-waterbound modes such as road-rail or rail-rail.

Basic structure of a port

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 up into multiple berths. A berth corresponds approximately to the length of an inland vessel, which is around 100 to 130 metres.

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 adjacent area is used as transhipment areas for indirect transhipment (e.g. containers from ships will be provisionally unloaded onto the quay and later brought to the container depot). The port area also consists of areas for industrial complexes

Source: via donau, EHG Ennshafen GmbH

Basic structure of a port

and logistics areas, which are available for logistics service providers who provide transhipment services to third parties.

A port concentrates and distributes traffic flows from the **hinterland**, which is the catchment area of the port. The size of this catchment area depends on an economic distance which is not only defined by the geographic distance in kilometres, but also by transport costs and transport time.

Types of ports

Sea-river ports such as the Danube Port of Galaţi in Romania or the Rhine Port of Duisburg in Germany can accomodate smaller sea vessels as well as inland vessels. However, **inland ports** may only accomodate inland vessels, due to smaller water depths.

Ports that tranship various goods, such as general or bulk cargo, are called **multi-purpose ports**. If a port handles only one kind of cargo, such as mineral oil, the term **specialised port** is used.

Infrastructure and suprastructure

Ports have both an infrastructure and a suprastructure. The **port's infrastructure** is formed by quay walls, rail tracks and roads, as well as paved surfaces. The **port's suprastructure** is built on the infrastructure and includes cranes, warehouses and office buildings.

Transhipment by type of cargo

In transport economics, a number of different **classifications of goods** can

Source: EHG Ennshafen GmbH

Port infrastructure / port suprastructure

be found. These classifications are frequently based on sectors and branches, the processing stage of the goods or their state of aggregation. The two-dimensional goods classification system chosen for the following illustration depicts the transhipment methods and the classification of the cargo, whereby a distinction is made between **general cargo** and **bulk cargo**.

<table>
<tr><th colspan="36">Cargo</th></tr>
<tr><th colspan="24">General cargo or break bulk</th><th colspan="12">Bulk cargo</th></tr>
<tr><td colspan="6">Roll-on-Roll-offe. g. cars</td><td colspan="6">High and heavy goods</td><td colspan="6">Container</td><td colspan="6">Other general cargo e. g. big bags</td><td colspan="6">Dry bulk
e. g. coal, ore, grain</td><td colspan="6">Liquid bulk
e. g. crude oil</td></tr>
<tr><td colspan="9">Ramps</td><td colspan="15">Hook, grabber, spreader, rope</td><td colspan="4">Grabber</td><td colspan="4">Suction equipment</td><td colspan="4">Pump</td></tr>
<tr><th colspan="36">Transhipment</th></tr>
</table>

Source: via donau

Transhipment by type of cargo

Performance of port transhipment equipment

The **performance** of port transhipment equipment is defined by the maximum lifting capacity as well as the hourly and/or daily output of each individual crane. Modern gantry cranes or mobile cranes can accommodate 30 tons with 20 metre outreach and thereby efficiently tranship full containers or heavy steel coils from vessel to quay or from truck to railway wagon.

With **Lift-on-Lift-off transhipment** (Lo-Lo) by cranes, the hourly output is estimated according to the number of crane cycles per hour, the capacity of the grabbers used (in inland ports usually between 2 and 15 m^3) and the specific weight of the goods handled. In specialized inland ports, up to 800 tons per hour of ore can be transhipped. The daily output of a port determines the time which an inland vessel spends in the port, thereby influencing the total costs of inland waterway transport.

Cranes and ramps

	Luffing and slewing crane, up to 15 t	Luffing and slewing crane, up to 30 t	Gantry crane (bridge) up to 40 t
Grab operation	120 t/h	160 t/h	200 t/h
Hook Operation	80 t/h	100 t/h	120 t/h
Spreader		15 Container/h	25 Container/h

Source: via donau

Performance of port transhipment equipment

Cranes are classified as gantry cranes, luffing and slewing cranes, mobile cranes or floating cranes. They can be distinguished by their features and hence with regard to their procurement and operating costs. The installation and acquisition of the cranes for specific terminals mainly depends on the types of goods being handled.

Gantry or portal cranes are primarily used for transhipping containers and can also be used for other cargo such as sheet metals and pipes. The capacity is, on average, around 25 containers per hour. Full utilisation of transhipping containers is achieved by using spreaders as specific lifting equipment.

Source: Mierka Donauhafen Krems

Gantry crane at the Port of Krems

A **luffing and slewing crane** is a multipurpose transhipment crane and is suited for transhipment of goods using hooks or grabbers. Procurement costs are significantly less than those of a bridge crane.

Mobile cranes can be used as primary equipment at a port and can also provide support for existing crane equipment.

Transhipping roll-on/roll-off units such as cars requires the ports to have ramp equipment. Numerous Danube ports are equipped with **Ro-Ro ramps**. A levelling ramp can be adapted to the respective water level with a cable

Source: via donau

Luffing and slewing crane at the Port of Vienna

Source: via donau

Mobile crane with caterpillar track system

Source: via donau

Ro-Ro ramp at the Port of Vienna-Freudenau

winch and thereby provides optimal utilisation of the ramp. The angle of the ramp must not be too steep, especially during cargo handling of trucks, large agricultural machines or heavy cargo.

Loading hoppers

Loading hoppers are used for the transhipment of bulk goods from an inland vessel to a railway wagon or to a truck. Due to the fact that an inland navigation vessel can carry far larger amounts than a truck trailer or a rail wagon, loading hoppers are needed in order to decouple the transhipment process in a short period of time. A crane loads the bulk goods from the inland vessel from above into the hopper, while trucks or railway wagons located under the

Source: Mierka Donauhafen Krems

Loading hoppers in the Port of Krems

hopper are being filled at the same time. Loading hoppers can also be used as a temporary storage facility.

Suction and pumping equipment

Special suction and pumping equipment is used for **transhipping liquid goods**. This equipment, so-called **fillers**, are connected to the tanker vessel using a swinging arm and the cargo is pumped directly into storage tanks or waiting railway wagons or trucks. Vice versa, tankers are filled from the ware-

Source: via donau

Transhipment facility for liquid cargo in the Port of Vienna-Lobau

house. Since the majority of liquid goods are classified as dangerous goods, these transhipment facilities are subject to stringent safety standards.

Floor-borne vehicles

Floor-borne vehicles are used for the horizontal transport of goods; they are mostly used in-company at ground level.

Reach stackers are wheeled vehicles which can tranship containers using spreaders. Such vehicles are predominantly used as a supplement to cranes or gantry cranes. Whereas a **forklift** can only hoist containers upwards in vertical direction, a reach stacker can also move containers forward by using an extendable lifting arm. This allows for the vertical storage of containers in piles, which can reach a height of 4 to 6 containers.

In addition to reach stackers, **full and empty container forklifts** can be used for the horizontal manipulation of containers. Forklifts are usually used for the efficient and safe transhipment of numerous goods such as round timber,

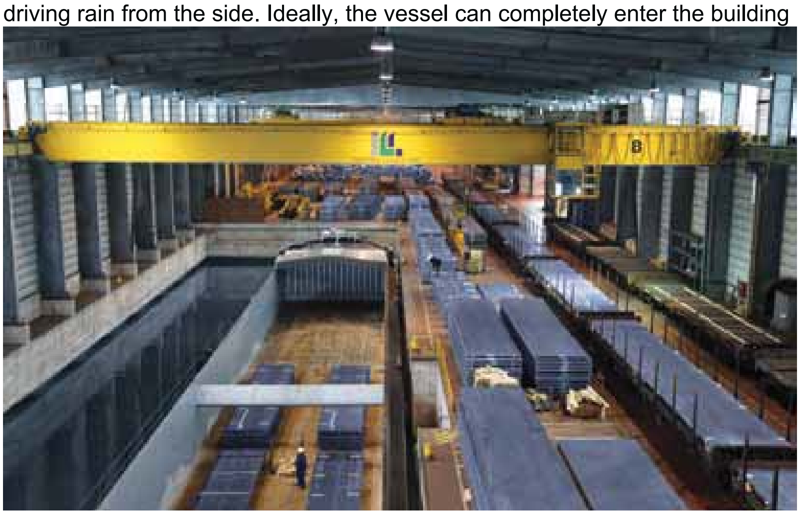
Source: WienCont Containergesellschaft mbH

Reach stacker at the Port of Vienna-Freudenau

paper rolls, steel rolls etc. and require special equipment, such as clamps or claws.

Covered transhipment

Transhipment of goods in a building that is cantilevered over the water and protected along the sides from the rain allows wetness-sensitive goods, such as salt, magnesite, grain or fertilizers, to be manoeuvred regardless of weather conditions. The construction of the roof above the inland vessels protects the cargo from direct rain and – depending on the construction – also against driving rain from the side. Ideally, the vessel can completely enter the building


Source: Industrie-Logistik-Linz GmbH & Co KG

Covered transhipment at the facility of Industrie-Logistik-Linz

which is similar to a garage. The transhipment in such halls is carried out by overhead gantries, which span both the storage area and the transport vessel.

Transhipment of bulk goods without grabbers

Bulk goods such as soya meal, grain, cement and fertilizers are most frequently transhipped without cranes or grabbers, but by means of **pneumatic or mechanical equipment**. When using pneumatic systems such as suction or pumping devices, the bulk goods are transported via fixed pipes or flexible hose connections with high pressure or suction. Mechanical systems such as conveyor belts, elevators and screw conveyars are also used in a similar way. In the case that only the loading of inland vessels is necessary, simple methods of transhipment such as tubes are also often used.

Heavy cargo transhipment

Heavy cargo transhipment requires special port infrastructure and suprastructure such as paved surfaces which can withstand an elevated floor pressure and suitable transhipment equipment, such as heavy-duty cranes.

Source: Felbermayr Transport & Hebetechnik GmbH & Co KG

The Austrian Heavy Cargo Port Felbermayr in Linz

Storage

Warehouses are becoming increasingly important due to the modernisation of commercial logistics, for example as **distribution warehouses** offering more added value thanks to supplementary services (value added services) such as commissioning.

The basic function of a warehouse is to serve as a buffer, which means the **collection and distribution of flows of goods**. This is especially important when using different transport modes, since the capacity differs according to the means of transport being chosen.

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 three different kinds of warehouses: storage warehouses, transhipment warehouses and distribution warehouses. With regards to **type of construction**, there are open storage facilities, covered storage facilities and special-purpose storage facilities.

Types of storage facilities			
Construction	Open	Covered	Sperial 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.

Source: via donau

Overview types of storage

Open storage

This is the place where non-sensitive goods are stored, e.g. ore. These goods have a comparatively low value and are not affected by rain or fluctuation of air temperature. Likewise, full and empty containers can be stored in open storage facilities because they are usually closed.

Source: via donau

Open storage

Covered storage

In a covered storage facility, goods are partly protected from adverse weather conditions and high value goods can be stored safely. In general, a covered storage facility is a storage area covered with a roof and located in a hall respectively.

Covered storage

Special storage

Special depots can be silos, tanks, bulk goods storage facilities, refrigerated storage or freezer storage.

Agricultural bulk goods such as grain, soya and corn are stored in **silo installations**. Such facilities allow the storage of seasonal goods over longer periods of time, while guaranteeing storage and treatment such as dehumidification without loss of quality to the product. Goods in silos can be used continuously or transhipped onwards to other modes of transport. **Storage tanks** are used for the storage of liquid goods and basically function in the same way as silo installations.

Some ports on the Danube have modern **storage facilities and boxes for bulk goods** at their disposal. These boxes have a special roof construction

Bulk goods storage

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Detailed data on storage capacities available in the Danube ports is available on www.danubeports.info.

with a wide opening, enabling the cargo to be unloaded directly from the vessel to the storage facility by crane. The goods are delivered as an entire vessel's load and transhipped directly into the boxes using gantry cranes with grabbers. Each box contains one type of raw material, ensuring that many different kinds of cargo can be stored, thus expanding the services provided by the ports.

Value-added logistics services

Ports have become increasingly multifunctional service providers over the last few decades. In addition to basic services such as transhipment and storage, ports offer an extensive range of **logistical services** such as the packing, stuffing and stripping of containers, commissioning, distribution (pre- and end-haulage) and project logistics. As **locations for commerce and industry** as well as **cargo handling centers**, ports contribute significantly to the creation of added value and employment. Due to the specialisation of comprehensive

Source: via donau

Container transhipment by Mainromline in the Romanian Danube Port of Giurgiu

logistical concepts and services, ports have extended their range with value-added services in the logistics fields of containers, Ro-Ro and heavy cargo.

Management models

Ownership-operation structure and type of service provision

According to the World Bank, ports can be divided into four categories (🗎 World Bank 2007): public service ports, tool ports, landlord ports and private service ports. The differentiating factors are:

- Public, private and mixed provision of services
- Ownership of the infrastructure (including land and property)
- Ownership of suprastructure and equipment
- Status of port workers and management

Ports also differ depending on their type of service provision towards third parties. Public service ports are accessible to everyone. Limited public ports are not accessible to everyone. In private service ports, transhipment is generally not available to third parties.

Source: Donau Chemie AG

Transhipment site of the Austrian company Donau Chemie AG

While public service ports and tool ports focus mainly on the realisation of public interests, fully privatised ports serve private interests. Landlord ports have a mixed character aiming at a balance between public (port operators) and private (port companies) interests.

- **Public service ports**: In this model, the port authority provides all services relevant to the functioning of the port system. The port owns and operates all available fixed and mobile facilities and maintains them. Port transhipment is performed by personnel who are directly employed by the port authority. The main functions of a public service port include cargo transhipment activities.
- **Tool ports** are primarily of a public nature. In this model the port infrastructure and port suprastructure are owned by the port authorities. The authority is also responsible for their further development and maintanance. However, the port authority also provides land and suprastructure

to private transhipment companies. These perform the transhipment by using their own staff.

- **Landlord ports**: The landlord model is predominent in large and medium-sized ports. While the port authority has the role of a public regulator and property owner (“landlord”), private companies carry out the port operation (especially cargo transhipment). The infrastructure is mainly leased by private companies such as refineries, tank terminals and chemical plants. Private transhipment companies provide the suprastructure including the buildings such as offices and storage and maintain them. Port personnel are employed either by private terminal operators or are also provided in some ports by a pool system.
- **Fully privatised 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.

	Owner	Infrastructure	Suprastructure	Labour force
Public service port	public	public	public	public
Tool port public	public	public	public	private
Landlord Port	public	public	private	private
Private Port	private	private	private	private

Source: World Bank 2007

Ownership-operator structure of inland ports

A clear allocation of ports to the four models is often difficult in practice, since numerous other **mixed combinations** exist. However, the four criterions have proven themselves in practice in the process of assessing the ownership-operator structure of a port, thereby providing an overview of the service provision at the port.

Management models of Austrian Danube ports

In the following table, the four public ports on the Austrian Danube (Hafen Linz AG, Ennshafen, Mierka Donauhafen Krems, Hafen Wien) and the factory port of voestalpine in Linz are grouped according to their ownership-operator structure.

Hafen Linz AG	Ennshafen	Mierka Donauhafen Krems	Hafen Wien	Factory port of voestalpine
Public service port with minor landlord activities	Mainly oriented towards landlord activities	Mainly oriented towards a tool port	Public service port with minor landlord activities	factory port

Source: via donau

Management models of Austrian Danube ports

Development trends

Specialisation of ports

The range of services offered by a port needs to be attractive to shippers and logistics service providers. In addition to **multi-purpose ports**, **specialized ports** also exist which focus their business on a particular type of cargo. The specialisation of a port to specific transport sectors can lead to competitive advantages. The port may specialise in a specific type of cargo on the basis of greater demand for such goods and/or increased cargo volumes in the hinterland of the port. For this reason multiple specialised terminals may be found in a port.

A form of specialisation is, for example, the field of high & heavy cargo. Heavy cargo ports, which are specialised in over-sized cargo, require special technical equipment together with specialised logistics solutions. Approved lifting technology and equipment with high load capacity are the prerequisite of a heavy cargo port.

Special transhipment equipment is also needed, for example, for the handling of liquid bulk goods such as liquified natural gas (LNG) or crude oil. Special suction and pumping equipment is required in the port for such operations. Due to the fact that the majority of transhipped liquid cargoes are dangerous goods, special safety precautions have to be observed in the port.

Green Ports

Green Ports, i. e. **sustainable port management**, is a trend which has become increasingly more predominant in the field of port development over the last few years. Green Ports aim to strike a balance between environmental impact and economic interests. The core of the “Europe 2020” strategy of the European Commission is sustainable growth (European Commission 2010a). Furthermore, national and regional political strategies are intended to lead to more sustainability in the field of port development. Together with the development of ports, the concept Green Ports also includes the total redesign of logistics chains.

Best practice: Green Terminal in Baja

On the Danube, the Hungarian port of Baja has intensely dealt with the Green Ports concept. In May 2011 a "Green Terminal" was established, which collects waste water, bilge water and general waste as well as ensuring the provision of ships with power and drinking water.

Source: Port of Baja

Green Terminal in the Hungarian Danube Port of Baja

Best practice: Shore power in the Port of Rotterdam

The Port of Rotterdam ensures shoreside provision of electricity for ships. These connect to shoreside electricity with their engines switched off, thereby ensuring that fuel consumption and emissions are reduced while improving the quality of air in the port as well as in the surrounding area. Additionally, in some Danube ports the subject of shore power is beginning to play an ever more important role. There are efforts in the course of European projects to equip additional berths in Danube ports with shoreside electricity supply.

Trend towards cooperation

In order to maintain a hold in an ever changing environment, both competition and cooperation are required. "Co-opetition", a combination of "competition" and "cooperation", is in line with this approach (🗎 Brandenburger & Nalebuff 1996). For this reason, ports in the same geographical region often cooperate with each other in areas such as marketing and locational development.

Cooperation of Austrian Danube ports

The **Interessengemeinschaft Öffentlicher Donauhäfen in Österreich (IGÖD)**, a community of interests made up of the four Austrian public

Source: Hafen Linz AG, Ennshafen, Hafen Wien, Mierka Donauhafen Krems

The ports represented in the community of interests of Austrian public Danube ports: Hafen Linz, Ennshafen, Mierka Donauhafen Krems, Hafen Wien (in clockwise direction)

Danube ports of Linz, Enns, Krems and Vienna, represents the ports at an international level. In addition, the transfer of knowledge between members and the enlargement of knowledge are core activities of IGÖD.

Transhipment points on the Danube

Transhipment points of Danube riparian states

According to the definition as laid down by the "European Agreement on Main Inland Waterways of International Importance (AGN)" (🗎 United Nations Economic Commission for Europe 2010), more than 40 Danube ports are classified as "**E-ports**", i.e. inland ports of international importance. The average distance between these ports on the Danube is approximately 60 kilometres, compared to the Rhine river basin where it is only 20 kilometres.

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Detailled information about Danube ports ar e available on www.danubeports.info

Transhipment points on the Austrian Danube

On the Austrian Danube, the significant transhipment points are located as follows:

Transhipment point	River-km	Type	Website & e-mail
Aschach an der Donau	2,160	Transhipment site	www.garant.co.at office@garant.co.at
Linz commercial port	2,131	Port	www.hafenlinz.at hafenlinz@linzag.at
Linz oil port	2,128	Port	www.hafenlinz.at hafenlinz@linzag.at
Linz – voestalpine	2,127	Port	www.voestalpine.com info@voestalpine.com
Linz – ILL	2,127	Port	www.ill.co.at office@ill.co.at
Linz Felbermayr*	2,125	Port	www.felbermayr.cc hafen@felbermayr.cc
Ennshafen	2,112	Port	www.ennshafen.at office@ennshafen.at
Ybbs	2,058	Port	www.hafen-ybbs.at office@schaufler-metalle.com
Pöchlarn	2,045	Transhipment site	www.garant.co.at office@garant.co.at
Mierka Donauhafen Krems	1,998	Port	www.mierka.com office@mierka.com
Pischelsdorf	1,972	Transhipment site	www.donau-chemie.at office@donau-chemie.at
Korneuburg – MOL	1,943	Transhipment site	www.molaustria.at office_wien@molaustria.com
Korneuburg – Agrarspeicher	1,941	Transhipment site	www.agrarspeicher.at office@agrarspeicher.at
Vienna-Freudenau	1,920	Port	www.hafen-wien.com office@hafenwien.com
Vienna-Albern	1,918	Port	www.hafen-wien.com office@hafenwien.com
Vienna-Lobau	1,917	Port	www.hafen-wien.com office@hafenwien.com
*located on the river Traun			

Source: via donau

Transhipment points on the Austrian Danube

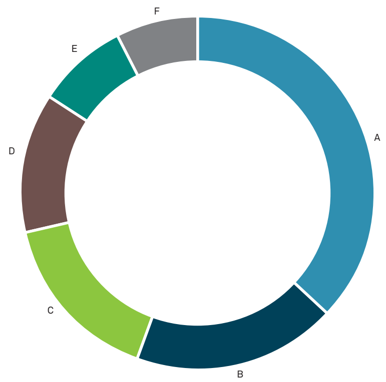
FIGURES_DATA_FACTS

Waterside transhipment at Austrian Danube ports and transhipment sites 2014

F
Krems
7.5%
641,641 tons
(+30.1%)

E
Enns
8.2%
708,244 tons
(–0.8%)

D
Linz AG[4]
12.8%
1,103,026 tons
(–5.5%)



A
Linz voestalpine[1]
37.1%
3,193,494 tons
(–10.3%)

B
Others[2]
18.5%
1,593,371 tons
(+27.2%)

C
Port of Vienna[3]
15.9%
1,371,534 tons
(–17.6%)

[1] Including waterside transhipment at Industrie Logistik Linz GmbH.
[2] Other ports and transhipment sites include: Aschach, the heavy cargo port at Linz, Pöchlarn, Pischelsdorf, Korneuburg.
[3] The three ports of Freudenau, Albern and Lobau (oil port), and the two transhipment sites Lagerhaus and Zwischenbrücken have been grouped together to compile the total turnover figures for the Port of Vienna.
[4] Data from both the commercial port and the oil port in Linz have been grouped together to compile the total turnover figures for the Port of Linz.

Source: Statistics Austria; adapted by viadonau

PORT TRANSHIPMENT

A slight decrease in total volumes Krems shows a significant increase

In 2014, a total of 8.6 million tons of goods were handled waterside at Austrian Danube ports and transhipment sites. Compared to 2013, this represents a decrease of 2.7% or 240,162 tons.

With a total handling volume of around 3.2 million tons, the port of voestalpine in Linz was once again the most quantitatively significant port on the Danube in Austria in 2014. Despite a turnover decrease of 10.3% or 366,921 tons compared to 2013, the port still handled 37.1% of the total waterside transhipment of all ports and transhipment sites on the Austrian Danube.

The other private ports and transhipment sites (including Aschach, the heavy-cargo port at Linz, Pöchlarn, Pischelsdorf and Korneuburg), were in second place with just under 1.6 million tons and 18.5% of the total volume of goods handled at Austrian loading and unloading points. A detailed analysis of the other ports and transhipment sites is not possible due to data protection laws.

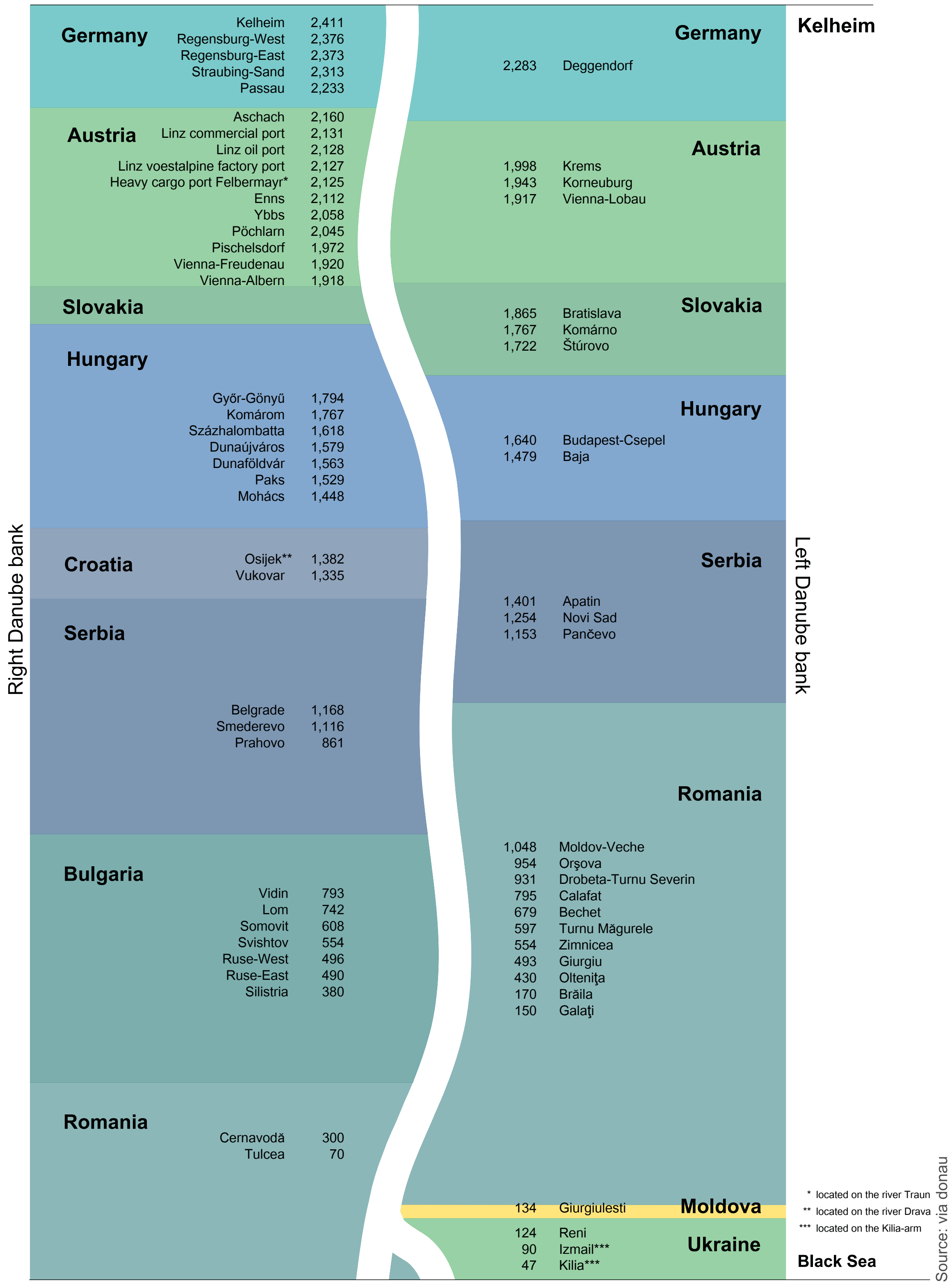
The Port of Vienna (Freudenau, Lobau and Albern along with the transhipment sites Lagerhaus and Zwischenbruecken) recorded a total of almost 1.4 million tons in water-land transhipment in 2014. This represents a decrease of 17.6% or 293,000 tons. The Port of Vienna accounted for 15.9% of total waterside transhipment in the Austrian section of the Danube.

The commercial port and the oil port owned by Linz AG saw a slight decrease of 5.5% or 63,759 tons of goods handled. With a total volume of around 1.1 million tons, the two ports accounted for 12.8% of all goods loaded and unloaded at Austrian ports and transhipment sites.

The Port of Enns remained relatively stable, handling 708,244 tons or 8.2% of Austria's total transhipment volume. This represents a slight decline of 0.8% in comparison to 2013.

The Port of Krems was the only public port on the Danube to increase its water-land transhipment in 2014. With a significant increase of 30.1% or 148,370 tons, the port accounted for 7.5% of the total goods handled at Austrian ports and transhipment sites. A total of 641,642 tons went through the port in 2014.

- voestalpine industrial port, with 3.2 million tons waterside transhipment, most important port on the Danube in Austria
- Significant plus of 30.1% at the Port of Krems
- Other ports and transhipment sites in second place for total transhipment in Austria with 18.5%



Significant ports and transhipment points on the Danube (including river-kilometres for their location)

Legal provisions

International regulations

European inland ports of international significance, the so-called “**Eports**”, are listed in the **European Agreement on Main Inland Waterways of International Importance (AGN)** (🗎 United Nations Economic Commission for Europe 2010). Eports should enable the operation of motor cargo vessels and convoys, which are navigating on the respective Ewaterway on which the Eport is located. Furthermore, the ports should have respective connections to roads of international importance and main international railway lines at their disposal. These should include the European road, rail and combined transport freight networks as stipulated in other conventions of the UNECE (i.e., the AGR, AGC and AGTC).

Eports should be able to carry an annual volume of cargo transhipment of a minimum 0.5 million tons and provide appropriate conditions for the development of port industrial areas. Moreover, the ports should facilitate the transhipment of standardised containers unless they are specialised exclusively for bulk goods transhipment.

Legal provisions in Austria

Legal regulations applying to ports and its users, vehicles and floating objects are embodied in the Austrian **Navigation Act** (Federal Law Gazette I 62/1997). The law includes, in addition to other regulations, the **§ 68 port fees for public ports**. For the use of public ports, port fees are charged based on tariffs. Port fees include pierage, demurrage and fees for mooring during winter time. The basis for the assessment of port fees are cargo transhipment and/or the type and size of the vehicles and floating objects.

As compensation, port facilities and services are available to users. In this framework the port basin including the mooring facilities, waste and waste oil collectors as well as sanitation facilities may be used. Moreover, the usage of drinking water for the ship’s crew and measures to keep ports free from ice are included. Private ports are also allowed to levy port fees.

The **Regulation for Shipping Facilities** (Federal Law Gazette II 298/2008) regulates the arrangement, operation and use of shipping facilities. This also includes regulations for other facilities on the waterway such as floating restaurants, hotels and stages.

River Information Services for Ports

Port and terminal operators benefit from the transparent and electronic exchange of information provided within the framework of River Information Services (RIS). Access to the **strategic traffic image** and the ETA (estimated time of arrival) calculated as part of the **voyage planning** process enable a better and more exact planning of port and transhipment operations. Additionally, **access to cargo data** transmitted via electronic reporting of dangerous goods facilitates proactive management of transhipment and storage activities. Access to ship and cargo data by ports and terminal operators requires the vessel operator's consent.

The ongoing monitoring of vessel positions in the framework of RIS allows, for example, the automatic registration of vessels' arrival and departure at ports, terminals or landing stages in the context of **berth management**. The arrival and departure times are recognised by RIS and can be computed for statistical or invoicing purposes. Such transfer of data also requires the prior consent of the vessel operator.

Source: via donau

Types of vessels on the Danube

Basically, inland cargo vessels operating on the river Danube and its navigable tributaries can be divided into three types according to the **combination of their propulsion systems and cargo holds**:

- **Motor cargo vessels** (or self-propelled vessels) are equipped with a motor drive and cargo hold. Motor cargo vessels can be subdivided into dry cargo vessels, motor tankers, container and Ro-Ro vessels (see below under "Main types of vessels according to cargo type")
- **Pushed convoys** consist of a pusher (motorised vessel used for pushing) and one or more non-motorised pushed lighters or pushed barges that are firmly attached to the pushing unit. We talk about a coupled formation or pushed-coupled convoy if a motor cargo vessel is used for propelling the formation or convoy instead of a pusher. A **coupled formation** consists of one motor cargo vessel with one to two lighters or barges coupled on its sides, whereas a **pushed-coupled convoy** has one to two lighters or barges coupled to the motor cargo vessel on its sides with additional lighters or barges placed in front of it.
- **Tugs** are used to tow non-motorised vessel units, so-called barges (vessels for carriage of goods with a helm for steering). Towed convoys are rarely used on the Danube any more because they are less cost-effective than pushed convoys.

Cargo shipping on the Danube is predominantly carried out by means of convoys (pushed convoys, coupled formations as well as pushed-coupled convoys), and only a small share by individual motor cargo vessels. On the Rhine, the ratio of convoys to motor cargo vessels is approximately the reverse.

Source: via donau

A 4-unit pushed convoy on the Austrian section of the Danube east of Vienna

Pushed navigation on the Danube

When comparing all types of vessels operating on the Danube, the **bulk freight capacity of pushed convoys** is clearly the most impressive. The term “bulk freight capacity” indicates the possibility of transporting a large amount of goods on a vessel at the same time. A pushed convoy comprising of one pusher and four non-motorised pushed lighters of the type Europe IIb, for example, can transport around 7,000 tons of goods - the equivalent to the cargo carried by 280 trucks (with 25 net tons each) or 175 rail wagons (with 40 net tons each). The 4-unit convoy mentioned above can navigate the whole stretch of the Danube between the German port of Passau and the Black Sea. Even more impressive is the transport capacity of a 9-unit convoy like those used on the Central and Lower Danube. Such a convoy can carry remarkable 15,750 tons of cargo and can therefore replace 630 trucks or 394 rail wagons (which is the equivalent of about 20 fully loaded block trains). Convoys comprising of up to 16 pushed lighters are possible on the lower reaches of the Danube due to the width of the waterway and the fact there are no limitations caused by locks.

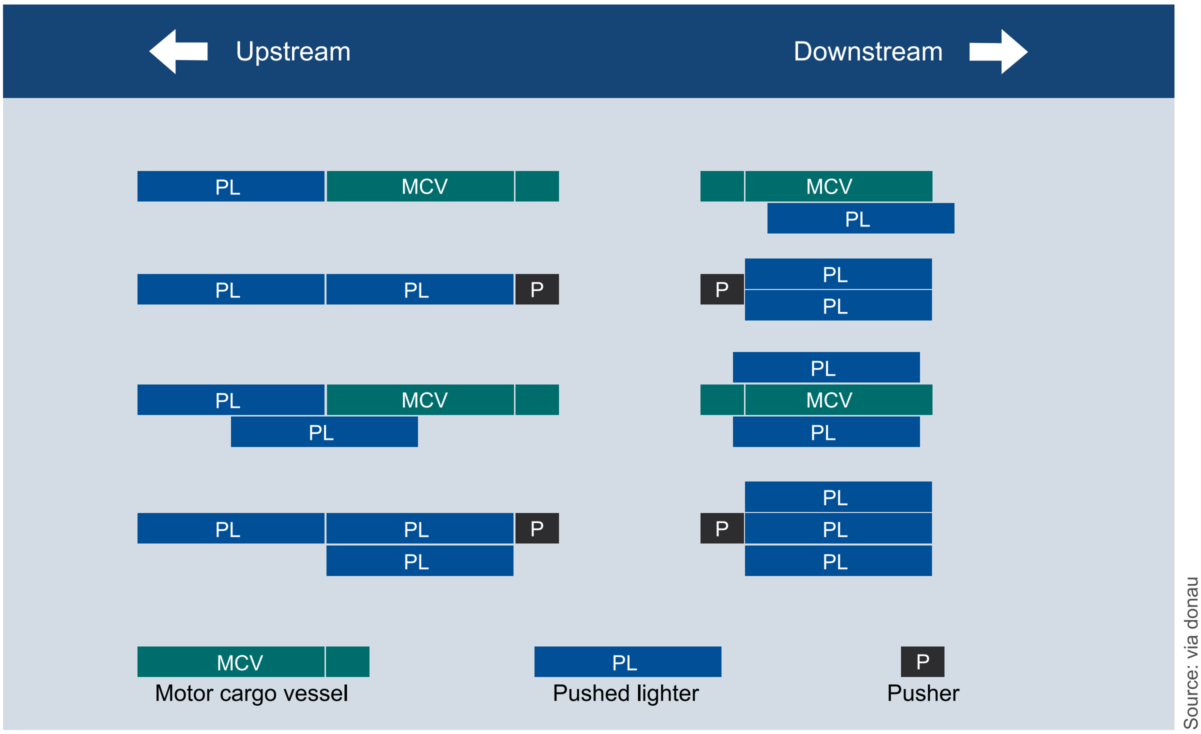
A Europe IIb type pushed lighter, which is typically used on the Danube, has the following dimensions: length 76.5 m, width 11.0 m, maximum draught 2.7 m with a load capacity of 1.700 tons.

The basic rule for the **formation of convoys** is: vessel units in pushed convoys are grouped so as to reduce water resistance when in motion as much as possible or so that sufficient stop and manoeuvre characteristics can be ensured (e.g. when navigating downstream). In order to lessen the resistance, the lighters are placed in a staggered arrangement towards the rear.

If the appropriate technical features of the units used in a convoy allow it, vessel units are not attached to one another rigidly, but rather coupled with

Source: via donau/Andi Bruckner

Pusher belonging to the TTS Line shipping company



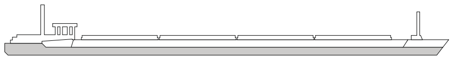
Arrangement of vessel formations on the Danube

flexible connectors to enable the convoy to negotiate curves in areas with particularly narrow curve radii.

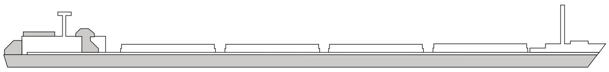
For **upstream** travel, the convoy should have as small a cross-sectional area as possible and thus the lowest possible resistance, which is why the lighters are arranged behind one another in a so-called cigar or asparagus formation. In contrast, the lighters are arranged next to each other together when travelling **downstream**, to facilitate the manoeuvrability of the convoy and most especially its ability to stop in the direction of the current.

Main types of vessels according to cargo type

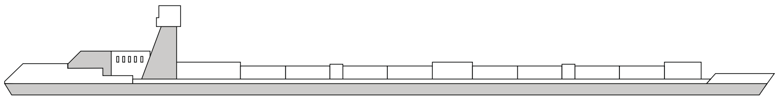
Dry cargo vessels are used for transporting a wide variety of goods including log wood, steel coils, grain and ore. These vessels can be used for almost anything and therefore reduce the number of empty runs (journeys with no return cargo). This class of vessel can generally carry between 1,000 and 2,000 tons of goods and is often used on the Danube in coupled formations or pushed-coupled convoys. Dry cargo vessels can be divided into the three main classes that are shown in the figure below.



Gustav Koenigs	
Length:	67 m
Width:	8.2 m
Max. draught:	2.5 m
Deadweight (dwt):	900 t



Europaschiff	
Length:	85 m
Width:	9.5 m
Max. draught:	2.5 m
Deadweight (dwt):	1,350 t



Large motor vessel	
Length:	95 m / 110 m
Width:	11.4 m / 11.4 m
Max. draught:	2.7 m / 3.5 m
Deadweight (dwt):	2,000 t / 3,000 t

Source: Voies navigables de France

Main types of dry cargo vessels

Source: via donau

Motor cargo vessel of the Europaschiff class

ADN = European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (🗎 United Nations Economie Commission for Europe 2008)

ADN-D = Standards Concerning the Transport of Dangerous Goods on the Danube (🗎 Donaukommission 2007)

Tankers transport various types of liquid goods, such as mineral oil and derivates (petrol, diesel, heating oil), chemical products (acids, bases, benzene, styrene, methanol) or liquid gas. The majority of the liquid goods mentioned above are hazardous goods which are transported using special tanker vessel units equipped with the appropriate safety devices. European regulations and recommendations, such as the ADN and ADN-D, as well as national legislation governing the transport of hazardous goods have particular relevance in this context.

Tankers used on the Danube have an average loading capacity of around 2,000 tons. As is the case with the navigation of dry cargoes, the transport of liquid goods on the Danube is carried out primarily by pushed convoys.

Modern tankers have a **double hull** which prevents the cargo from leaking in the event that the outer hull is damaged. Stainless steel tanks or cargo holds with a **special coating** are used in order to prevent the cargo from reacting with the surface of the tank. The use of heaters and valves enable the transport of goods that freeze easily even in winter, and sprinkler systems on deck protect the tanks from the summer heat. Liquid gases are transported under

Tanker	
Length:	110 m
Width:	11.4 m
Max. draught:	2.8 m
Deadweight (dwt):	2,300 t

Source: via donau

Main characteristics of a tanker

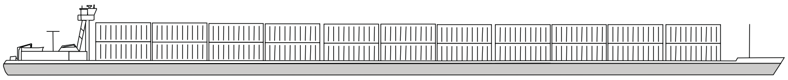
Source: helmut1972, www.binnenschifferforum.de

Tanker on the Danube

pressure and in a cooled state using special containers. Most tankers have pumps on board which can load and unload the goods directly into the tanks in ports not equipped with such special loading systems.

Container vessels are ships constructed specifically for the transport of containers and are currently used primarily in the Rhine region. In the Danube region container convoys with four pushed lighters are regarded as the best way to increase capacity. Such a pushed convoy has a total loading capacity of up to 576 TEU – each pushed lighter can therefore carry 144 TEU, i.e. three layers of containers with 48 TEU each.

TEU = Twenty-Foot Equivalent Unit. TEU is the measurement used for containerised goods and is equivalent to a container with the standard dimensions of 20 feet x 8.5 feet x 8.5 feet (around 33 m³).



Container vessel	
Length:	135 m
Width:	17.0 m
Max. draught:	3.7 m
Deadweight (dwt):	470 TEU

Source: Voies navigables de France

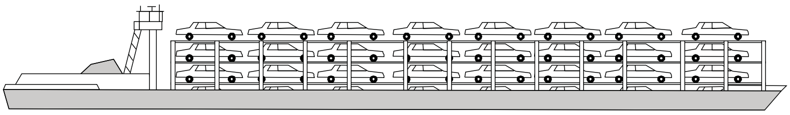
JOWI class Rhine container vessel

Source: via donau

Container convoy entering the Austrian Port of Linz

Ro-Ro vessels: Roll-on-Roll-off means that the goods being transported can be loaded and unloaded using their own motive power via port or vessel ramps. The most important types of goods transported in this way include passenger cars, construction and agricultural machinery, articulated vehicles and semi-trailers ("floating road") as well as heavy cargo and oversized goods.

The majority of Ro-Ro transport operations are carried out with specially constructed vessels such as catamarans. **Catamarans** are vessels with a double



Ro-Ro vessel	
Length:	105 m
Width:	9.5 m
Max. draught:	1.4 m

270 x 

Type parameters of a Ro-Ro vessel

Source: Voies navigables de France

Ro-Ro catamaran on the Danube

Source: helmut1972, www.binnenschifferforum.de

hull in which the two hulls are connected by the deck, which forms a large loading surface for the rolling goods.

@

Information on passenger navigation is provided by the Danube Tourist Commission: www.danube-river.org

Passenger vessels

The Danube has become significantly more attractive in recent years, even for longer river cruises along its whole stretch between the Main-Danube Canal and its Black Sea estuary. As a logical consequence of this trend, the number of orders for new passenger vessels is also rising. New **cruise or cabin vessels** for navigation on the large waterways of Europe set top standards as far as comfort, safety and nautical properties are concerned. Large river cruise vessels that are 125 metres long offer space for around 200 passengers who are usually accommodated in 2-bed cabins. Thanks to their dimensions, these vessels can pass through locks 12 metres in width and can therefore be used along the whole stretch of the river between the North Sea and the Black Sea.

A low draught of on average 1.5 metres, plus ingeniously constructed super-

Source: via donau/Andi Bruckner

Cabin vessel on the Danube

structures and deckhouses ensure smooth operation in very low water depths and safe passage under bridges in periods with higher water levels. The recent use of diesel-electric propulsion systems with gondola propellers now guarantees virtually silent operation as well as enabling relatively high speeds of up to 24 km/h in shallow waters.

In addition to the cabin vessels used for long-haul navigation, there are also **day-trip vessels** that usually only operate local liner services. These passenger vessels are used mainly for day trips, round trips and charter trips on the more attractive stretches of the Danube or for round trips in or to larger cities located along the Danube.

The Danube fleet

Due to the economic model that prevailed in the eastern area of the Danube region until the political reforms of the 1980s, **large shipping companies** are still dominant on the Danube. Starting in the early 1990s, these shipping companies have been successively privatised. This is quite the opposite to the situation on the Rhine where small "one-ship companies", i.e. private vessel owner-operators, are predominant.

With very few exceptions these large Danube shipping companies use large **pushed convoys** (occasionally still towed convoys) for transporting bulk cargo due to the relatively low gradient of the Danube in its middle and lower stretches. The share of cargo space of non-self-propelled units in the Danube fleet stood, for example, at around 71% at the end of 2010 according to statistics published by the Danube Commission. In absolute figures, this amounted

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The figures quoted here for the Danube fleet do not include the vessel units of Western European countries such as Germany or the Netherlands that operate for the main part with self-propelled vessels in exchange traffic with the Main and the Rhine.

Pushed convoy of the Romanian company C.N.F.R. NAVROM S.A. at the Iron Gate

to **1,933 pushed lighters** with an average tons deadweight of almost 1,400 and **790 towed barges** with and average tons deadweight of 800. In the past, a considerable number of towed barges were re-equipped for pushing and have therefore not yet been decommissioned.

In the year 2010, the fleet of motorised units in pushed convoys comprised, in total, of **412 pushers** with an average output of 1,130 kW. In addition, there were still 275 tugs in operation on the Danube in the same year.

A **pushed convoy** on the Danube is on average 20 years old. The pushed convoys from Romania and especially the Ukraine are by far the largest and youngest on the Danube.

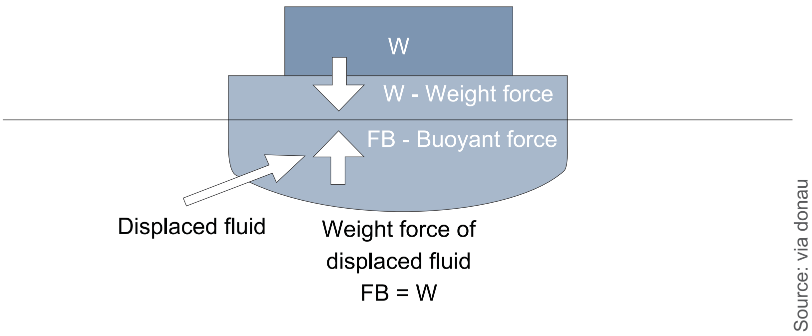
In contrast to the Rhine region, the proportion of **self-propelled units with a cargo hold** of 29% in the Danube fleet is relatively low. There were **403 motor cargo vessels** registered in the Danube riparian countries in operation in the year 2010; these had an average output of 550 kW and an average deadweight of 1,010 tons. However, the formerly extremely low proportion of self-propelled vessels on the Danube has risen in recent years due mainly to the decommissioning of older barges and lighters as well as the purchase or acquisition of second-hand motor cargo vessels from the Rhine Corridor. Motor cargo vessels on the Danube are between 18 and 32 years old. Newer cargo vessels for operation on the Danube and its navigable tributaries are still a rare exception.

In the year 2011, there were around **130 cruise vessels** with the capacity to accommodate 20,000 passengers operating on the Danube. The cruise vessels in operation on the Danube are on average 12 years old with around five new vessels a year being commissioned in the last few years. There are currently no reliable figures available for the total number of **day-trip vessels** in operation in the Danube region.

Physical and technical aspects

Archimedes' Principle

The Archimedes' Principle was first discovered by Archimedes of Syracuse. It states: "Any object, immersed in a fluid, is **buoyed up** by a **force equal to the weight** of the fluid displaced by the object." This discovery represented the theoretic underpinning of a physical fact that had been used for the transport of goods, animals and people by waterway for several thousands of years before Archimedes.

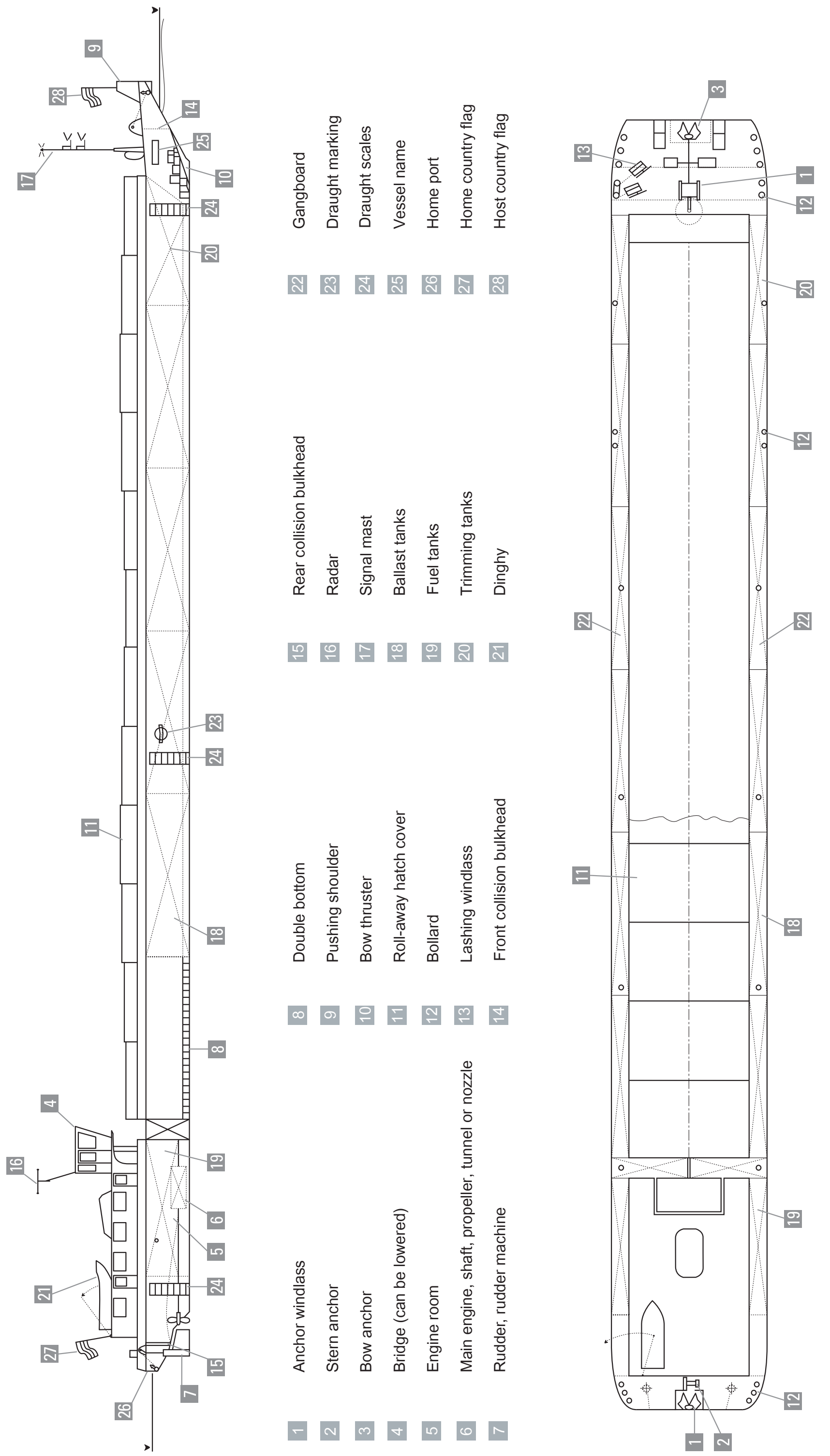


The Archimedes' Principle applied to ships

With respect to a ship, the Archimedes' Principle means that the buoyancy of a ship is equal to the weight of the fluid displaced by the ship (see graphic). The immersion depth of the ship is adjusted in such a way that the buoyancy is equal to the weight of the ship. If a ship is loaded, its weight increases and the ship immerses further into the water simultaneously, and it immerses so far that the weight of the additionally displaced water balances the weight of the additional load. As water has a density of approximately 1 t/m^3, exactly 1 m^3 of water is displaced for each additional ton of ship mass. Therefore, the design of the ship in particular, i.e. its length and width as well as the shape of its hull, and the construction material used determine the tare weight of the ship and its possible maximum load.

Hydrodynamic resistance

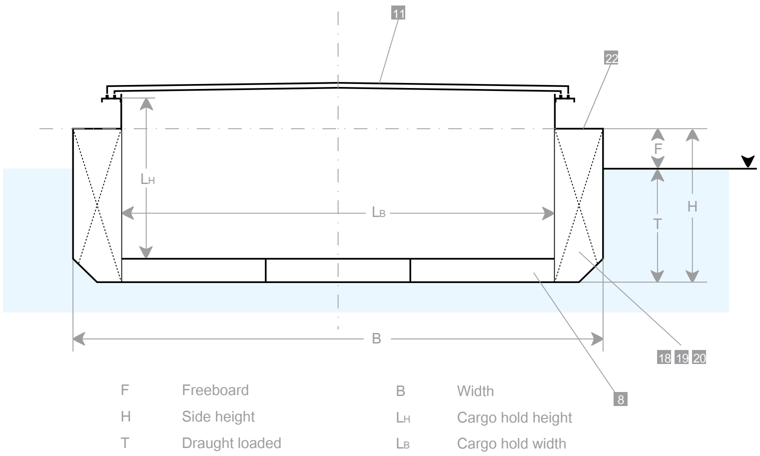
When a ship moves through water it experiences a force acting against its



Source: Helogistics Holding GmbH, via donau

The most important components of an inland waterway vessel based on the example of a “DDSG-Steinklasse” motor cargo pusher

Key data	
Length	95 m
Width	11.4 m
Side height	3.2 m
Draught loaded	2.7 m
Fixed point above base	6.5 m
Maximum tons deadweight	2,000 t
Hatch length	69.5 m
Hatch width	8.8 m
Fuel tank	110 m^3
Ballast tank	380 m^3
Potable water tank	38 m^3



Source: Helogistics Holding GmbH, via donau

Key data and cross section of a "DDSG-Steinklasse" motor cargo pusher

direction of motion. This force is the resistance to the motion of the ship and is referred to as total resistance. A ship's total resistance is a function of many factors, including ship **speed**, the **shape of the hull** (draught, width, length, wetted surface), the **depth and width of the fairway** and **water temperature**. The total resistance is proportional to the wetted surface and the square of the ship's speed. The hydrodynamic resistance of a ship increases in shallow waters and its manoeuvrability is reduced which in turn increases the fuel consumption of the ship.

Components of an inland waterway vessel

The most important designations and dimensions of a Danube cargo vessel are depicted on the following page based on the example of a "DDSG-Steinklasse" **motor cargo pusher** (large motor vessel). This type of vessel is used as a drive unit in coupled and pushed-coupled convoys for the most part due to it being equipped with pushing shoulders.

Propulsion and steering systems

A ship's motion through the water is enabled by its propulsion and steering devices. The most common propulsive device used for ships is the **propeller** due to its simplicity and its robustness. It consists of several blades (two to seven) that are arranged around a central shaft and functions like a rotating screw or wing. Three, four or five blade propellers are the types used most often. High blade numbers reduce vibrations but increase production costs.

Due to the problems of seasonal low water on certain sections of the Danube self-propelled Danube vessels are usually **twin-screw ships**, i.e. equipped with two propellers. In the case of twin-screw propulsion the propellers have a smaller diameter and so remain completely immersed even if the draught of the vessel is significantly lower. Due to the higher investment costs, the total fuel consumption in deeper waters and the costs of maintenance and repair this propulsion system is more expensive than the single-screw types used predominantly on the Rhine.

Usually only **one screw** and one main engine are used in relatively deep waters in order to save costs. Single screw propulsion is technically possible (from a hydrodynamic point of view) and also completely justified with regard to cost effectiveness in the case of a “standard vessel” with an output of between 700 and 1,000 kW, a width of 11.4 metres and a normal draught of 2.5 metres.

The most usual and simplest steering device for a ship is the **rudder**. Steering a ship means having control over her direction of motion. The working principle of a rudder is similar to that of an aerofoil. The flow of water around the rudder blade in inclined position generates a transversal force tending to move the stern opposite to the rudder inclination. The common characteristic of all rudders is that the generated transversal force depends on the flow velocity around the rudder: the higher the velocity, the stronger the rudder effect. The transversal force also depends on the cross-sectional and rudder shape, rudder area and the angle of attack.

Modernisation of the inland waterway fleet

Framework conditions

Based on centuries of experience, Danube navigation has adapted to the predominant fairway conditions on the river. This is also in line with the legal traffic regulations, because according to the “Convention Regarding the Regime of Navigation on the Danube” from the Danube Commission (§ 1.06 – Utilisation of the waterway) cargo vessels must in principle be adapted to the conditions of the waterway (and its facilities) before they are permitted to navigate it (🗎 Danube Commission 2010).

Nevertheless, in order to further exploit existing potential in the field of ship design, hydrodynamic parameters such as shape, propulsion and manoeuvrability are being continuously optimised. However, technical innovations can only contribute to the further optimisation of cargo vessels within the **given physical and economic limitations** – the overall system of vessel-waterway must be kept in view and what is technically possible combined with what is economically viable. Cargo shipping must remain economically competitive if it is to survive the fierce competition with road and rail – only those transport operations on the Danube that have a competitive price-performance ratio are ever carried out.

Modernisation potential

The average age of the European inland waterway fleet is rather high. New vessels are often built according to standard designs developed decades ago. However, there are many technical alternatives for improvement of the existing fleet relating to hydrodynamics and engine systems.

With regard to **hydrodynamics** improved propulsive efficiency and manoeuvrability as well as reduced resistance (modification of the ship's hull) are the most important factors and can be achieved with already existing technologies. With regard to **engine systems**, the most important areas for modernisation are the reduction of fuel consumption and exhaust gas emissions as well as compliance with strict emission regulations.

Improvement of propulsive efficiency and manoeuvrability

A reduction in fuel consumption can be achieved by improving the propulsive efficiency of the vessel or by reducing its resistance in water. The **propulsive efficiency** can, for example, be increased by the following technologies:

- **Ducted propeller (Kort nozzle)**: A propeller that is fitted with a non-rotating nozzle, which improves the open water efficiency of the propulsive device. The advantages of the ducted propeller include increased efficiency, better course stability and lower susceptibility to damage caused by foreign bodies.
- **Z-drive (SCHOTTEL rudder propeller)**: A rudder propeller is a robust combination of propulsion and steering devices, whereby the drive shaft is deflected to the propeller twice at an angle of 90° giving it the form of a Z. As the underwater components can be turned through 360°, the system enables maximum manoeuvrability. Other advantages include optimum efficiency, economical operation, space-saving installation and simple maintenance.
- **Azipod propulsion devices**: This system consists of a rotating gondola that hangs below the ship's stern and that fulfils both propulsion and steering functions. The propeller is driven by an electric motor fitted inside the gondola. The advantages of the propulsion gondolas include among other things reduced exhaust gas emissions, fuel savings due to improved hydrodynamic efficiency, good manoeuvring properties, flexible machinery arrangement and space-saving in general arrangements.
- **Controllable pitch propeller**: The pitch of the propeller blades of a controllable pitch propeller can be adjusted to the existing operating

Source: Ludovic Péron

Twin-screw propulsion with ducted propellers

Source: Schottel GmbH

SCHOTTEL Rudder propeller (Z-drive)

conditions leading to achievement of the maximum open water efficiency.

- **Adjustable tunnel**: A device at the stern of the vessel consisting of fins which can be folded down to create a tunnel in the direction of the propeller. This prevents air suction in shallow water operation in a partly loaded condition with the result that the propeller remains fully functional even if operated in extremely shallow water.
- **Pre-swirl duct**: The purpose of this device is to improve the incoming flow to the propeller resulting in increased propeller efficiency and a reduction in the propeller loading (and as a result a possible cavitation), in vibrations and in fuel consumption.
- **Propeller boss cap fins**: An energy-saving device that breaks up the hub vortex that forms behind the rotating propeller. This reduces the torque of the propeller and increases fuel efficiency by three to five per cent.

The **manoeuvrability** of a vessel can sometimes be improved by applying simple measures. Such measures include adding end plates to the rudder or increasing the rudder area, resulting in an increased rudder force. Studies have shown that the rudder area is one of the most important parameters for course keeping and the turning abilities of a ship. Many rudder shapes and improvement measures have been developed over the years in order to improve manoeuvring efficiency and increase navigation safety. Below are a few examples:


Source: Brosen

Bow thruster

- **Schilling rudder**: A high-performance fishtail rudder whose single piece construction with optimised shape and no moving parts improves both course keeping and vessel control characteristics.
- **Flap rudder**: These rudders consist of a movable rudder with a trailing edge flap (comparable to an aerofoil with a flap) which enable a much higher lift per rudder angle and a 60 to 70% higher maximum lift compared to conventional rudders.
- **Bow thruster**: With the help of vertically mounted propellers (propeller shafts) water is drawn up from underneath the vessel. The water is guided into one or two channels at an angle of 90° by a drum rotating at 360° making the vessel manoeuvrable. A major advantage of this system is that maximum thrust can be achieved with minimum draught without any parts protruding through the ship's hull.
- **Articulated coupling**: An articulated coupling between a pusher and a pushed lighter comprising a hydraulically operated flexible coupling to facilitate steering in sharply meandering sections of the waterway.
- **Dismountable bow filling for coupled vessels**: The gap between a pusher and a pushed lighter impacts on smooth flow around the formation. Installation of a flexible bow filling between the pusher and the lighter

is a simple way of reducing vortex formation and separation.

Improvement of emission characteristics

It would appear that **diesel engines** will remain the most common form of propulsion for inland navigation in the medium term. **Gas engines** are feasible long-term options. Fuel cells are in their infant stage of application and need further long-term development. These present great potential for a significant reduction in the emissions of inland vessels.

Legislation with regard to emissions is getting stricter and environmental friendliness is becoming an ever greater key to competitive advantage. For this reason, it is necessary to optimise engines with regard to fuel consumption and emission characteristics. The **diesel engines** currently in operation in inland waterway transport are emission-optimised engines and their **specific fuel consumption** is approximately 0.2 kg/kWh. This value has remained unchanged for several years due to the fact that nitrogen oxide emissions had to be reduced at the expense of fuel consumption. The average age of a ship's engine before it has to be replaced is around 15 years or more. If you compare this to the average service life of truck engines, which is five years, it is obvious that it will take much longer to fulfil emission standards in inland navigation.

The EU Directive 2009/30/EC came into force in January 2011, setting the limit to the sulphur content of the fuels used in inland navigation at 0.001% (10 ppm) which has led to a reduction in SOx emissions of virtually 100%.

Possible measures for reducing the emission characteristics of ship engines include the following:

- Reduction of sulphuric oxide emissions:
    - Low-sulphur fuel
- Reduction of hydrocarbon and carbon monoxide emissions:
    - Diesel oxidation catalysts (require low-sulphur fuel)
- Reduction of nitric oxide emissions:
    - Exhaust gas recirculation (requires low-sulphur fuel)
    - Humidification of engine inlet air
    - In-cylinder water injection
    - Use of an emulsion comprising water and fuel
    - Selective catalytic reduction (i.e. injection of a reduction agent for the effective removal of nitric oxide emissions)
- Reduction of particulate matter emissions:
    - Particulate matter filters (PMF, require low-sulphur fuel)

According to the results of international research projects and experiments, the most effective techniques regarding the reduction of engine emissions and fuel consumption are:

- Engines for liquefied natural gas (LNG)
- Low-sulphur fuel

- Diesel oxidation catalysts (require low-sulphur fuel)
- Selective catalytic reduction
- Particulate matter filters
- Advising Tempomaat (ATM – a computer-aided system giving information about the most economical speed and minimum fuel consumption of the ship's engines based on prior inclusion of the calculation for limitations of the navigated waterway)

River Information Services on board ship

A ship's voyage goes through different phases: planning, the start, the voyage itself and the end. There are various River Information Services available that can be used on board ship during these different phases of the voyage. These are described in detail in the following.

RIS for support with planning

Certain preparations have to be made before the start of a voyage. River Information Services such as voyage planning or electronic reporting of hazardous goods can be used to support planning.

Source: via donau

RIS for support with planning ships voyages

Voyage planning is defined as the planning of the route, including all stopovers, the amount and type of the cargo to be loaded and the time schedule. Particular emphasis is placed on planning the vessel's maximum cargo load, which depends primarily on the available water levels.

Voyage planning software applications are usually commercial products sold by different suppliers. In addition to the basic functions, the software may also include other features, such as a combination with the strategic traffic image, stowage calculation or fuel saving algorithms, depending on the individual supplier. However, the basic function of all systems is the use of data relating to fairway information and general information on vessel movements. The factors taken into consideration include for example:

- Journey and average speed of the vessel
- Any speed limits that might apply on part sections
- Effects of flow directions and speeds
- Locking times
- Average waiting times at locks
- Traffic density, which has to be entered by the boatmaster

Voyage planning also offers the possibility of entering only the port of departure and port of destination as well as the weight of the cargo. On the basis of these factors, the application informs the shipping company which vessel is best suited for a particular voyage and a particular cargo.

Depending on national or international legislation, shipping operators must notify different authorities of the planned voyage and the cargo on board. Thanks to the use of **Electronic Reporting**, data relating to the cargo and voyage only need to be entered once.

More information about electronic reporting can be found in the chapter “River Information Services”.

RIS for support with navigation

On board the vessel, information about the current traffic situation aids navigation of the inland waterway (information mode). The area in the vicinity of a ship is displayed on a **tactical traffic image** on an on-board electronic inland navigational chart (inland ENC). The exact display of the boatmaster’s own ship and indication of the position and data of other vessels are valuable information for mastering challenging nautical situations, especially in unknown sections of the route.

Source: via donau/Andi Bruckner

Display of current traffic conditions on an electronic navigational chart

The **navigation mode** is defined as the use of inland ECDIS while steering the vessel by radar with a chart image in the background. This entails first linking the ECDIS application to a GPS system so that the current position

More information on Austria's mandatory requirement to carry and operate a transponder can be found in the chapter "River Information Services".

of the vessel is known at all times and is displayed on the navigational chart accordingly. Finally, the radar image is superimposed on the digital chart and the inland ECDIS application adjusted automatically. The total alignment of direction, orientation and displayed distance achieved in this way is called "radar map matching".

RIS on board in Austria

The River Information Services available for boatmasters on board their vessels in Austria include tactical traffic images, fairway information, tools for route planning and electronic hazardous goods reporting systems. Use of these services is voluntary. However, for harmonised vessel identification on the Austrian section of the Danube, Austria has put into force a **requirement for carrying and operating a transponder**.

Source: via donau

Mandatory vessel equipment with an optional ECDIS viewer in Austria

To enable the easier and more cost-saving use of some River Information Services, via donau – as the operator of the DoRIS system – has installed two free **WLAN hotspots** on the Austrian Danube. Users of the waterway can access navigational-relevant information from the Internet free of charge via WLAN in the vicinity of the locks Abwinden and Freudenau.

Crew members on inland vessels

An inland vessel is operated by a crew comprising of different members with different competencies and tasks. The **minimum crew** for inland vessels and the **composition of the crew** depends on the size and equipment of the vessel and on its operating structure.

Recommendations with respect to the crew of inland vessels can be found in

Source: via donau/Andi Bruckner

WLAN hotspot at the Vienna-Freudenau lock, which has been installed within the scope of the EU-co-funded project NEWADA

Chapter 23 of **Resolution No. 61 of the United Nations Economic Commission for Europe** (UNECE) concerning the technical requirements for inland vessels (🗎 United Nations Economic Commission for Europe 2011). The minimum crew number and composition as well as the competencies of crew members are regulated by national legislation along the Danube. On the Rhine, the relevant requirements are laid down by the Rhine Vessel Inspection Regulations (🗎 Central Commission for the Navigation of the Rhine 2011).

For Austria the regulations on inland vessel crews are defined in the "Schiffsbesatzungsverordnung" (Federal Law Gazette II 518/2004).

Overview of crew members

The crew prescribed for the respective operating modes must be on board the vessel at all times while it is underway. Departure is not permitted without the prescribed number of minimum crew. The number of members of the minimum crew for motor cargo vessels, pushers and vessel convoys depends on the length of the vessel or convoy and the respective **mode of operation**. The following distinctions are made for modes of operation:

- **A1**: Daytime navigation for maximum 14 hours within a period of 24 hours
- **A2**: Semi-continuous navigation for not more than 18 hours within a period of 24 hours
- **B**: Continuous navigation for 24 hours and more

The **minimum crew** required for safe operation of a vessel can consist of the following crew members:

Captain (boatmaster)	Sole person responsible on the vessel in matters of expertise and staff, holder of a captain's certificate and hence entitled to operate a vessel on the sections of the waterway indicated in the certificate	
Helmsman	Assistant to the captain	
Deck crew	Complete crew with the exception of the engineering staff; carries out various assistant tasks during the journey; consists of:	
	Boatswain	Slightly superior member of the deck crew
	Crewman	Inferior member of the deck crew
	Deckman	Unskilled beginner
	Ship's boy (ordinary seaman)	Member of the crew still undergoing training
Engine-minder	Monitors and maintains the propulsion motor and the necessary concomitant systems	
Pilot	Instructs the captain on board in specific, nautically difficult waterway sections	

Source: via donau

Crew members and their tasks

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Information on education, training and certification in inland navigation is provided on the website of Education in Inland Navigation: www.edinna.eu

Initial and further training for inland navigation

Initial and further training is very different in the individual Danube countries as well as in Europe as a whole. The approaches vary from very practically orientated concepts with no obligation to attend a training institute right through to achieving academic qualifications. Some countries have several courses of education running parallel to each other.

Education in Inland Navigation (EDINNA), the association of inland waterway navigation schools and training institutes in Europe, provides an overview of the training opportunities in Europe on its website. EDINNA supports the European Commission in its efforts to harmonise education and certification in inland navigation.

Source: via donau/Reinhard Reidinger

Crewmen connecting a tank lighter