RE WWay
Research & Education in Inland Waterway Logistics

LOGISTIKUM
viadonau

READER – THE INTERNATIONAL WATERWAY OF THE DANUBE

Extract of relevant passages from the „Manual of Danube Navigation”, via donau (2019) and of other relevant sources.

Pictures: viadonau in Manual on Danube Navigation (2019), p 79, 106

Source: viadonau/Thomas Bierbaumer

Motor cargo vessel entering the lock at Ybbs-Persenbeug

The capacity of the Danube waterway is a key factor within the inland navigation system. It is determined above all by the **nautical conditions** (meaning the navigability of the waterway with an economically viable draught loaded of the vessels over the course of the year); these factors directly influence the loading capacities of the vessel types in operation. Good nautical conditions and suitable, ongoing maintenance of the waterway infrastructure allow shipping companies to offer reliable and competitive transport services. This is a significant precondition for the sustained integration of green inland navigation within the logistical concepts of a modern economy.

Danube ports

Inland ports enable **the combination of the transport modes waterway, road and rail**. Working in multimodal logistics chains, rail and road act as partners to waterway transport by enabling the pre- and end-haulage of inland navigation transports. The ports are the important interfaces in this regard.

Over recent decades, the Danube ports have underwent profound transformation from conventional inland ports to modern **logistics hubs**. In addition to basic services such as transhipment and storage, ports offer an extensive range of logistics services, including commissioning, distribution, project logistics and many more. As production sites as well as cargo collection and distribution centers, they are extremely well integrated into regional economies and contribute substantially to economic growth and the creation of employment.

The three **most important Danube port locations in terms of transhipment** are Izmail (Ukraine), Linz (Austria) und Galaţi (Romania). The seaport at Constanţa (Romania) has a particular status. It is connected to the Danube via the Danube-Black Sea Canal and plays an important role as a transhipment gateway to the Black Sea, thereby facilitating trade with Asia, the Middle East and the Black Sea region.

Inland vessels

Essentially, a distinction can be made between two types of inland vessel used for cargo transport: **Motor cargo vessels**, which are equipped with an engine and a cargo hold, and **vessel convoys** comprising a motor cargo vessel or pusher and one or more non-motorised pushed lighters that are connected to the pushing vessel.

The main goods that are transported on the Danube and its navigable tributaries belong to the groups of ores, metal products, mineral-based raw materials, petroleum products and agricultural commodities.

Besides cargo transport, **passenger transport** is playing an increasingly important role as well. River cruises especially are becoming more and more popular. As a result, the number and quality of passenger vessels deployed on the Danube are rising.

Logistics solutions by inland vessel

The Danube is of particular importance as a transport mode for many trading and industrial companies located along the Danube corridor. Bulk freight capacity, low transport costs and free capacities all add up to make inland navigation **the logical partner for resource-intensive industries**. Project cargo (especially high & heavy cargo) and other high-quality general cargo are now being transported on the Danube in ever increasing numbers in addition to traditional bulk cargo.

In this manual, we are seeking to provide decision-makers in the logistics sector with all the expertise they need on logistics solutions by inland vessel. The success stories and practical examples included in the manual are explicitly intended as invitations to emulate these options.

The chapters 'Logistics solutions: The market for Danube navigation' and 'Logistics solutions: Multimodal transport' provide a clear overview of the possible uses for inland navigation. They also describe in more detail the logistics service providers represented on the Danube, as well as business and legal aspects.

Austrian transport policies have introduced a large number of initiatives to support the use of the Danube waterway.

River Information Services

A cornerstone of the technological modernisation of inland navigation has been the implementation of River Information Services, or RIS for short. RIS are tailored **information and management services** for inland navigation that raise transport safety and help improve the cost-effectiveness, reliability and plannability of transports. They include electronic navigational charts, tracking and tracing of vessels or current online information on water levels.

Strengths and weaknesses of Danube navigation

The principal **strengths** of Danube navigation are the ability to transport large quantities of goods per vessel unit, its low transport costs and its environmental friendliness. Furthermore, it is available around the clock, with no prohibition on driving at weekends or during the night and can provide a high degree of safety and low infrastructure costs.

The **weaknesses** lie in its dependence on fluctuating fairway conditions and the consequent, varying degree of the vessel load factor, the low transport speed and network density, which often necessitate pre- and end-haulage by road or rail.

The **opportunities** of Danube navigation are the high free capacities of the waterway, international development initiatives such as the Strategy for the Danube Region, the internalisation of external costs at European level, cooperation with road and rail, as well as the use of modern and harmonised River Information Services (RIS).

The **threats** to Danube navigation are found in the different political and hence budgetary importance assigned to this transport mode in the individual Danube states, as well as in the need to modernise many Danube ports and parts of the Danube fleet.

STRENGTHS

- Low transport costs
- Bulk freight capacity
- Environmental friendliness
- Safety
- Availability around the clock
- Low infrastructure costs

WEAKNESSES

- Dependence on variable fairway conditions
- Low transport speed
- Low network density, often requiring pre-/end-haulage

OPPORTUNITIES

- Free capacities of the waterway
- Rising demand for green transport modes
- Modern and internationally harmonised information services (RIS)
- Cooperation with road and rail
- International development initiatives (e.g. Strategy for the Danube Region)

THREATS

- Inadequate maintenance of the waterway in some Danube riparian countries
- Administrative barriers lead to competitive disadvantages (e.g. time-consuming/expensive checks)
- High requirement to modernise the ports and fleets

Source: viadonau

SWOT analysis of Danube navigation

Infrastructure costs

Infrastructure costs are comprised of the **costs for building and maintaining transport routes**. As in most cases it is possible to make use of the inland waterways as natural infrastructure, the infrastructure costs are low for inland navigation. Detailed comparisons with land transport modes in Germany are available: They indicate that the infrastructure costs per tonne-kilometre for road and rail are four times higher than for waterways (PLANCO Consulting & Bundesanstalt für Gewässerkunde, 2007).

Current cost estimates of infrastructure projects in the riparian states suggest that improving the complete infrastructure of the 2,415 km Danube waterway would cost 1.2 billion Euros in total. This is more or less equivalent to the costs of constructing around 50 km of road or rail infrastructure. Current European rail tunnel projects each cost 10 to 20 billion Euros.

Relevance of Danube navigation

Danube waterway transport in a European comparison

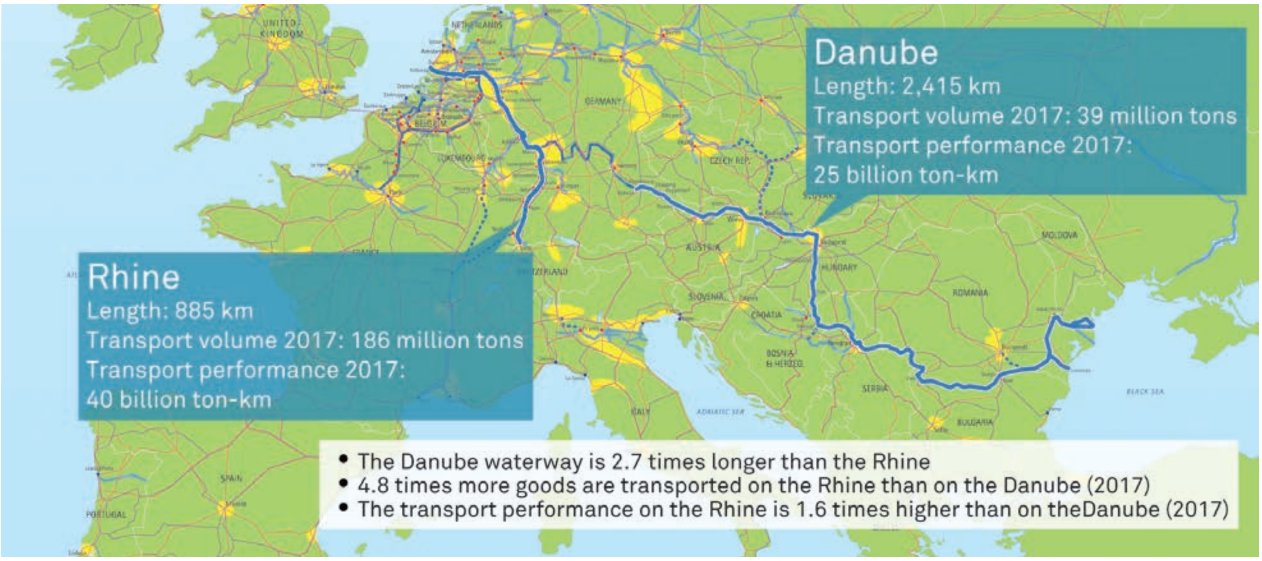
Statistical data for the EU-28 countries were taken from the online database of Eurostat, the statistical office of the European Union: ec.europa.eu/eurostat; this comprises of estimated and preliminary values. Values for the Danube region are based on enquiries by viadonau, which were conducted on the basis of national statistics.

In total, 558 million tons of goods were transported on **the inland waterways of the European Union** in 2017. The transport performance was 147 billion ton-kilometres. Accordingly, the average distance of waterway freight transport was 263 km.

The **Main-Danube Canal** creates an important basis for the 3,500 km, central Rhine-Main-Danube inland waterway, which extends through all of European mainland from the Port of Rotterdam on the North Sea to the Seaport of Constanţa on the Black Sea. With a transport volume of 186 million tons, the **Rhine** has significantly higher utilisation than the **Danube**, which was used to transport 39 million tons in 2017. Nonetheless, goods are transported for longer distances on the Danube, as shown by the transport performance for these two key European waterways: 25 billion ton-kilometres on the Danube (mean transport distance approx. 600 km) compared to 40 billion ton-kilometres on the Rhine (mean transport distance approx. 200 km).

If one considers the **transport volumes** along the Danube waterway and its navigable tributaries **in the individual Danube riparian states**, by far the largest transport volume for 2017 was recorded by Romania with 19.1 million tons, followed by Serbia with 12.5 million tons and Austria with 9.5 million tons.

Maritime transport on the Danube, i.e. transport on river-sea or sea-going vessels on the Lower Danube (Romania and Ukraine), accounted for 5.8 million tons in 2017, whereby the majority was transported via the Sulina Canal.



Source: viadonau, Central Commission for the Navigation of the Rhine

The European inland waterways Rhine and Danube in comparison

Modal split

In the **28 countries of the European Union**, waterways made up a 6.0% share of the modal split in 2017 – which means that 6.0% of all freight ton-kilometres were handled on waterways. This share differs sharply in the individual EU states. The Netherlands, for instance, have important seaports and a highly integrated inland waterway network which is divided into small sections. This results in the highest inland navigation share of the 28 EU countries (44.7% in 2017).

The infrastructural circumstances in the **Danube region** are different: Goods transport by waterway is concentrated on one main river. While it is able to transport very large quantities of freight to some extent, the small number of branches also means that it can only be used in focused regional areas. The Danube is therefore confined to a limited form of transport requiring longer pre- and end-haulage by road and rail. This is why the waterways tend to account for a smaller share of the national modal split in the countries of the Danube region.

Danube freight transport in Austria

In a longtime average, around 10 million tons of goods are transported on the Austrian Danube each year. Around a third of these goods are ores and scrap metals, while petroleum products, agricultural products and forestry products each account for around one eighth of the transported goods.

The waterway share in the modal split in the Austrian Danube corridor is roughly 10%. The Danube plays an important role mainly in upstream transport, especially in imports via the eastern border. In this area, the Danube is approximately neck and neck with rail transports.

Detailed statistics on the topic of transportation in the European Union: epp.eurostat.ec.europa.eu

Statistics on Danube navigation from the Danube Commission: www.danubecommission.org

Annual reports on Danube navigation in Austria are published by viadonau and are available to download at www.viadonau.org

Belgrade Convention

The **Convention Regarding the Regime of Navigation on the Danube** was signed by all Danube riparian states ('Belgrade Convention' of 1948). Its main objectives are to safeguard the freedom of navigation on the Danube for all states as well as to oblige the Danube states to maintain their sections of the Danube waterway to a navigable condition.

The signatory states of the Belgrade Convention are Bulgaria, Germany, Croatia, Moldova, Austria, Romania, Russia, Serbia, Slovakia, Ukraine and Hungary.

Source: INTERACT

Area of application of the Danube Strategy

The implementation of the Belgrade Convention, together with adherence to its provisions, is supervised by the **Danube Commission** which is based in Budapest. The Commission is made up of the signatory states of the Belgrade Convention.

Further information about the Danube Commission, including the text of the Belgrade Convention: www.danubecommission.org

Danube River Protection Convention

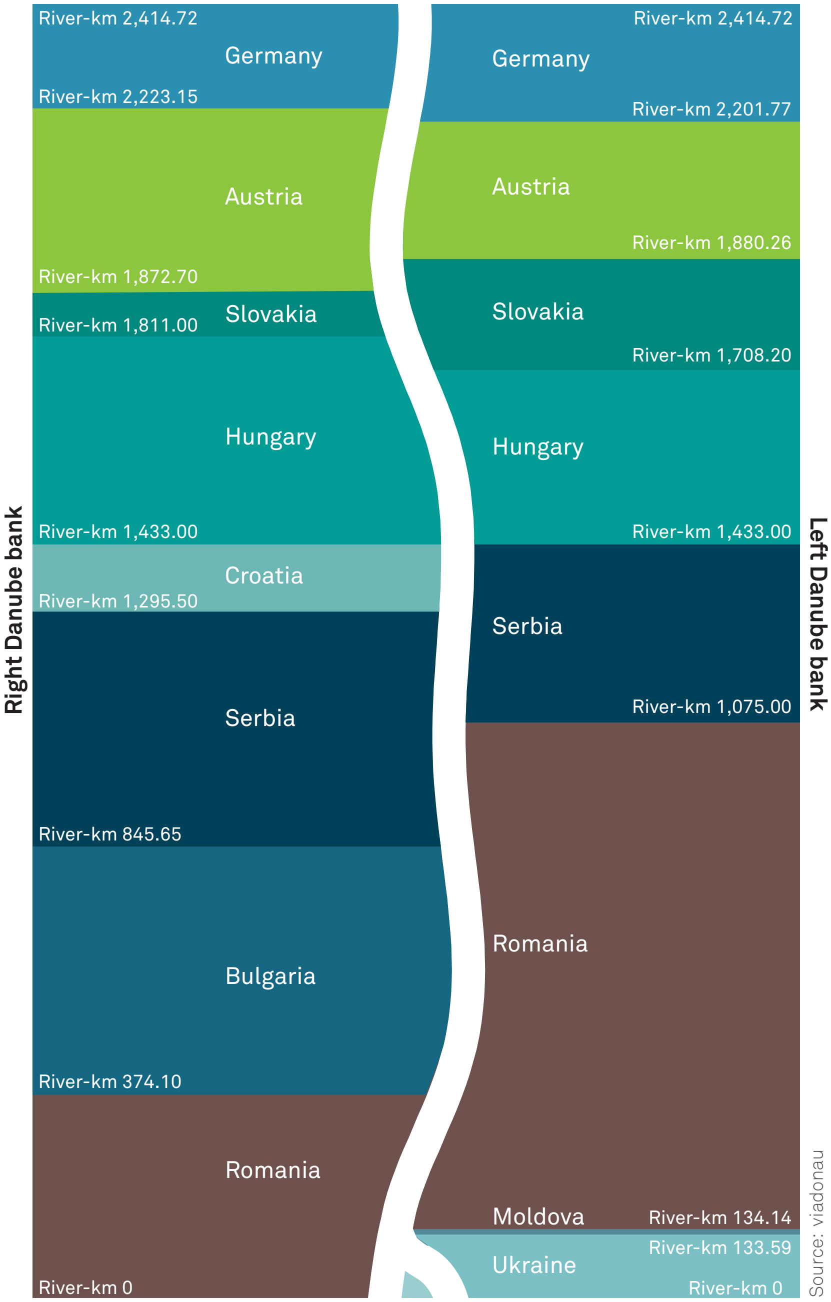
The International Commission for the Protection of the Danube River (ICPDR) was founded in 1998 and is located in Vienna. The dedicated aim of the ‚Danube River Protection Commission' is the implementation of the **Convention on Cooperation for the Protection and Sustainable Use of the Danube River** ('Danube River Protection Convention') as well as that of the Water Framework Directive (WFD) of the European Union in the Danube region. The signatories of this convention – along with members of the commission – are 14 Danube states and the European Union.

Further information about the Danube River Protection Commission and the Danube River Protection Convention: www.icpdr.org

The Danube and its tributaries

Geopolitical dimensions

On its way from the Black Forest, in Germany, to its mouth in the Black Sea in Romania and the Ukraine, the Danube passes through **ten riparian states**, which makes it the most international river in the world.



Danube riparian states and common border stretches on the navigable Danube waterway

With a total length of 1,075 kilometres, Romania has the **largest share of the Danube**, representing almost a third of the entire length of the river. Thereof, some 470 kilometres make up the common state border with Bulgaria. Moldova has the **smallest share of the Danube** with only 550 metres. Four countries, i.e. Croatia, Bulgaria, Moldova and Ukraine, are situated on only one bank of the river.

The Danube marks a **state border** along 1,025 km of its length, which corresponds to 36% of its entire length (calculated from the confluence of the Breg and Brigach headstreams in Germany to Sulina at the end of the Danube's middle delta distributary in Romania) or to 42% of its navigable length (Danube waterway from Kelheim to Sulina).

Source: viadonau/Pilo Pichler

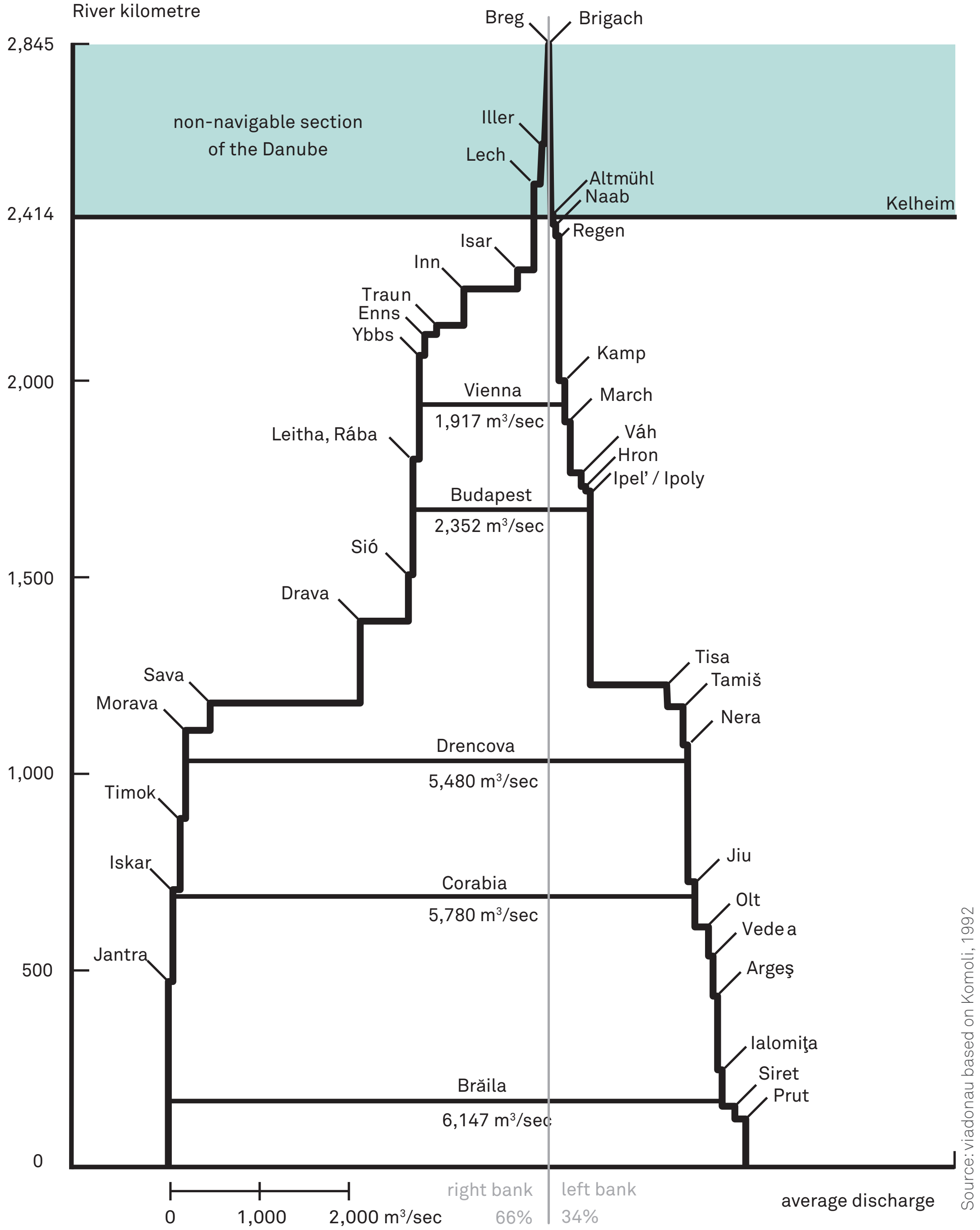
River basin district and discharge

The **river basin district** is the catchment area where all water from land surfaces, streams and ground water sources drains into the respective river. The river basin of the Danube covers **801,463 km²**. It lies to the west of the Black Sea in Central and South-Eastern Europe.

The diagram on the following page shows the structure of the **average discharge** for the entire length of the Danube, depicting the water distribution of the Danube's main tributaries and their geographical position (right bank, left bank). The term 'discharge' refers to the amount of water which passes by at a certain spot of the watercourse over a specific unit of time. Generally, discharge is indicated in cubic metres per second (m³/sec). At its mouth, the Danube has an average discharge of about 6,550 m³/sec, which makes the Danube the **river with the highest runoff in Europe.**

In terms of average inflow, the **five major tributaries** of the Danube are the Sava (1,564 m³/sec), Tisa/Tisza/Tysa (794 m³/sec), Inn (735 m³/sec), Drava/Drau (577m³/sec) and Siret (240 m³/sec).

The **longest tributary of the Danube** is the Tisa/Tisza/Tysa with a length of 966 kilometres, followed by the Prut (950 kilometres), Drava/Drau (893 kilometres), Sava (861 kilometres) and Olt (615 kilometres).



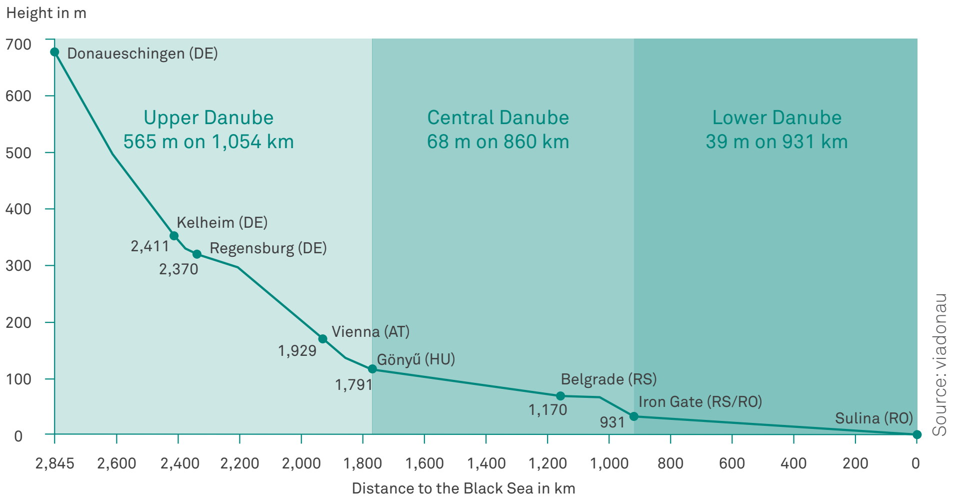
Average discharge of the Danube from its source to its mouth, based on data for the years 1941–2001

Length and gradient

With a **length of 2,845 kilometres**, the Danube is Europe's second-longest river after the Volga. In one of its first hydrographic publications, the European Danube Commission, which was established in 1856, stated that the Danube originates at the confluence of its two large **headstreams, the Breg and the Brigach**, at Donaueschingen in the **Black Forest** in Germany and that from this confluence the river has a length of 2,845 kilometres (measured to its mouth in the Black Sea at river-km 0 in Sulina at the middle distributary of the Danube delta). When measuring the distance from the origin of the **longer of the two headstreams, the Breg**, at Furtwangen to the Black Sea at Sulina, the overall length amounts to **2,888 kilometres**.

Due to the high gradient in the **first third** of its course (over a length of 1,055 kilometres), the upper part of the Danube has the characteristics of a **mountain river**. For this reason, nearly all river power plants, taking advantage of the gradient of a watercourse, are located on this part of the Danube. Only after the change of gradient at Gönyű in the north of Hungary (river-km 1,791) does the river gradually change into a lowland river.

While the **Upper Danube** has an average height difference of slightly more than 0.5 metres per kilometre, the average height difference on the **Lower Danube** is only slightly more than 4 centimetres per kilometre. The following illustration shows the **gradient curve of the Danube** from its source at Donaueschingen to its mouth in the Black Sea.



Gradient curve of the Upper, Central and Lower Danube

Classification of inland waterways

Working Party on Inland Water Transport of the UNECE's Inland Transport Committee: www.unece.org/trans/main/sc3/sc3.html

A **waterway** is a body of surface water serving as a route of transport for goods and/or passengers by means of vessels. Navigable inland transport routes are called inland waterways. Natural inland waterways are provided by **rivers** and **lakes**, whereas **canals** are artificial waterways.

In order to create the most uniform conditions possible for the development, maintenance and commercial use of Europe's inland waterways, in 1996 the Inland Transport Committee of the United Nations Economic Commission for Europe (UNECE) adopted the **European Agreement on Main Inland Waterways of International Importance** (AGN) (United Nations Economic Commission for Europe, 2010). The Agreement, which came into force in 1999, constitutes an international legal framework for the planning of the development and maintenance of the European inland waterway network and for ports of international importance, and is based on technical and operational parameters.

By ratifying the Agreement, the contracting parties express their intention to implement the coordinated plan for the development and construction of the so-called E waterway network. 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 waterways are designated by the letter 'E' followed by a number or a combination of numbers, whereby main inland waterways are identified by two-digit numbers and branches by four- or six-digit numbers (for branches of branches). The **international waterway of the Danube** is designated as **E 80**, and its navigable tributary the **Sava**, for example, as **E 80-12**.

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.

The class of an inland waterway is determined by the **maximum dimensions of the vessels** which are able to operate on this waterway. Decisive factors in this respect are the **width** and **length** of inland vessels and convoys, as they constitute fixed reference parameters. Restrictions regarding the **minimum draught loaded** of vessels, which is set at 2.50 metres for an international waterway, as well as the **minimum height under bridges** (5.25 metres in relation to the highest navigable water level) can be made only as an exception for existing waterways.

The following table shows the parameters of international **waterway classes based on type of vessels and convoys** which can navigate the waterway of the respective class.

Motor cargo vessels						
Type of vessel: general characteristics						
Waterway 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
VIa	Large Rhine vessel	95-110	11.4	2.5-2.8	1,500-3,000	7.00 / 9.10
VIb	Large Rhine vessel	140	15.0	3.9	1,500-3,000	7.00 / 9.10
VIc	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

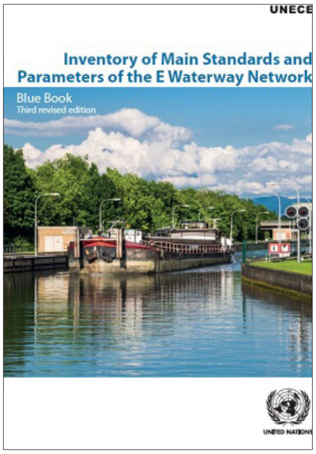
Pushed convoys						
Type of convoy: general characteristics						
Waterway class	Formation	Length L (m)	Width B (m)	Draught d (m)	Deadweight T (t)	Min. height under bridges H (m)
IV		85	9.5	2.5-2.8	1,250-1,450	5.25 / 7.00
Va		95-110	11.4	2.5-4.5	1,600-3,000	5.25 / 7.00 / 9.10
Vb		172-185	11.4	2.5-4.5	3,200-6,000	5.25 / 7.00 / 9.10
VIa		95-110	22.8	2.5-4.5	3,200-6,000	7.00 / 9.10
VIb		185-195	22.8	2.5-4.5	6,400-12,000	7.00 / 9.10
VIc		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

Source: United Nations Economic Commission for Europe, 2010

Waterway classes according to the AGN

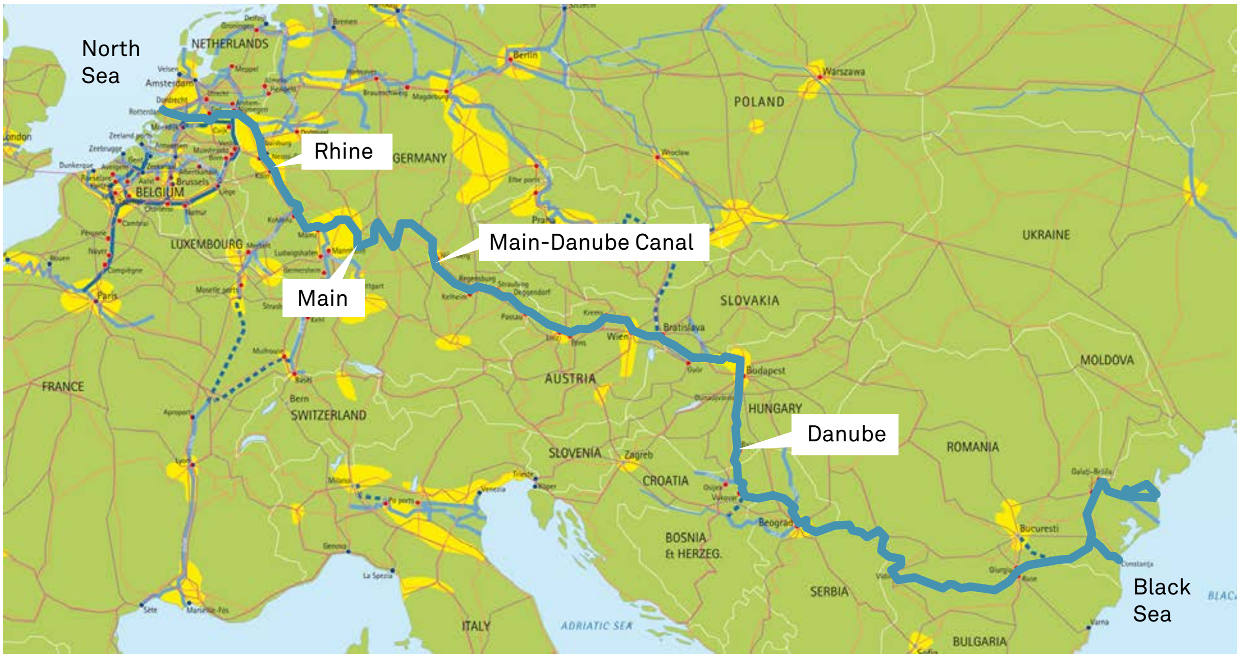
In 1998, the UNECE Inland Transport Committee first published an **Inventory of Main Standards and Parameters of the E Waterway Network**, the so-called 'Blue Book', as a supplement to the AGN (United Nations Economic Commission for Europe, 2012). The 'Blue Book' contains a list of the current and planned standards and parameters of the E waterway network (including ports and locks) as well as an overview of the existing infrastructural bottlenecks and missing links. This publication, which supplements the AGN, allows for the monitoring of the current state of implementation of the agreement on an international basis.

@ 'Blue Book' database: www.unece.org/trans/main/sc3/bluebook_database.html



The international Danube waterway

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 Canal** was opened to navigation in 1992 and created an international waterway between the North Sea in the West and the Black Sea in the East. This waterway has a total length of 3,504 kilometres and provides a direct waterway connection between 15 European countries.



Source: viadonau, Inland Navigation Europe

The inland waterway axis Rhine-Main-Danube

Danube Commission: www.danubecommission.org

The **navigable length of the Danube** available to international waterway freight transport is just under **2,415 kilometres**, starting from Sulina at the end of the middle Danube distributary into the Black Sea in Romania (river-km 0) to the end of the Danube as a German federal waterway at Kelheim (river-km 2,414.72). The Kelheim–Sulina main route is subject to the **Convention Regarding the Regime of Navigation on the Danube** of 18 August 1948 ('Belgrade Convention'), which ensures free navigation on the Danube for all commercial vessels sailing under the flags of all nations.

For more information concerning the Danube Commission and the Belgrade Convention, refer to the chapter 'Objectives and Strategies'.

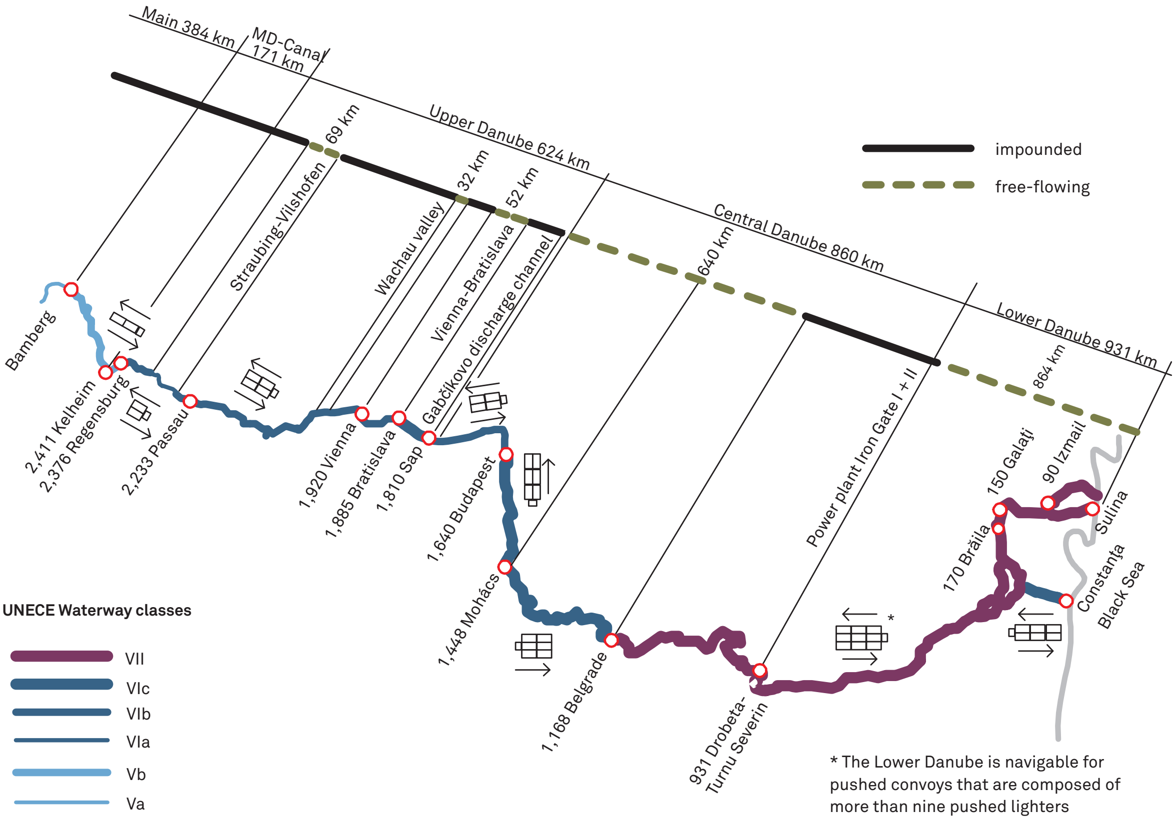
According to the definition of the Danube Commission, the international Danube waterway can be subdivided into three main sections for which the nautical characteristics are provided in the following table. This division into **three main sections** is based on the physical-geographical characteristics of the Danube river.

	Upper Danube Kelheim – Gönyű	Central Danube Gönyű – 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

Source: viadonau, Danube Commission

Nautical characteristics of the different Danube sections

The **waterway classes** of the various sections of the Danube and the **largest possible vessel units** (convoys) which are able to operate on these sections are shown in the following diagram. This diagram also includes the differences in the possible combinations of vessels in convoys for upstream and downstream travel as well as the impounded and free-flowing sections of the Danube waterway.



Source: viadonau

Maximum possible dimensions of convoys on the Danube waterway according to waterway classes

From **Regensburg to Budapest** (except for the Straubing–Vilshofen section in Bavaria) the Danube is classified as waterway class VIb and is navigable by 4-unit pushed convoys. The 69-km nautical bottleneck between Straubing and Vilshofen on the Bavarian section of the Danube is classified as waterway class VIa and is navigable by 2-lane 2-unit convoys.

Between **Budapest and Belgrade** the Danube is basically navigable by 2-lane and 3-lane 6-unit convoys. Here, the Danube is classified as waterway class VIc.

On the section downstream from **Belgrade to the Danube delta** (Belgrade–Tulcea) the Danube is classified as waterway class VII (highest class according to the UNECE classification). This entire section is navigable by 9-unit convoys while some subsections are suitable for even larger convoys.

Apart from the Kelheim–Sulina main route, several **navigable distributaries and side arms, canals** and **tributaries** form an integral part of the Danube waterway system. Apart from the Kelheim–Sulina section, all other transport routes are **national waterways** which are each subject to different regulations. The table on the following page provides an overview of these waterways.

The **length of navigable waterways in the Danube basin** (Danube including all navigable distributaries and side arms, canals and tributaries) comes to approximately 6,300 kilometres. 58% or **3,600 kilometres** of these are **waterways of international importance**, i.e. waterways of UNECE class IV or higher.

Source: viadonau

Overview of the waterways in the Danube region

Name of waterway	Riparian countries	Navigable length	UNECE Waterway class	Number of locks
Distributaries of the Danube:				
Kilia arm / Bystroe arm	Romania + Ukraine	116.60 km	VII / VIa	0
Sulina arm	Romania	62.97 km	VII	0
Sfântul Gheorghe arm	Romania	108.50 km	VIb + Vb	0
Side arms of the Danube:				
Bala / Borcea	Romania	116.60 km	VII	0
Măcin	Romania	98.00 km	III	0
Szentendre	Hungary	32.00 km	III	0
Canals:				
Danube-Black Sea Canal	Romania	64.41 km	VIc	2
Poarta Albă-Midia Năvodari Canal	Romania	27.50 km	Vb	2
Hidrosistem Dunav-Tisa-Dunav	Serbia	657.50 km	I - III	15
Main-Danube Canal	Germany	170.78 km	Vb	16
Tributatries of the Danube:				
Prut	Moldova + Romania	407.00 km	II	0
Sava	Serbia + Croatia + Bosnia and Herzegovina	586.00 km	III + IV	0
Tisa/Tisza	Serbia + Hungary	685.00 km	I - IV	3
Drava/Dráva	Croatia + Hungary	198.60 km	I - IV	0
Váh	Slovakia	78.85 km	VIa	2

Source: viadonau

Important waterways in the Danube region

System elements of waterway infrastructure

The size of inland vessels or convoys suitable for specific inland waterways depends mainly on the current **infrastructure parameters of the waterway** in question. The following factors of waterway infrastructure influence navigation:

- Waterway and fairway (depth and width, curve radii)
- Lock chambers (available length and width of lock chambers, depth at pointing sill)
- Bridges and overhead lines (clearance and available passage width under bridges and overhead lines)

In context with these determinants there are **further framework conditions** which may influence navigation on a certain waterway section:

- Waterway police regulations (e.g. maximum permissible dimensions of vessel units, limitations on the formation of convoys)
- Traffic regulations (e.g. one-way traffic only, maximum permissible speed on canals or in danger areas)

- Navigation restrictions and suspensions due to adverse weather conditions (floods, ice formation), maintenance and construction works at locks, accidents, events etc.

Water levels and gauges of reference

A **water gauge** measures the gauge height which corresponds to the height of water at a certain point in the reference profile of a body of water, i.e. the **water level**. In general, gauge heights are measured several times a day. Nowadays, they are also published on the Internet by the national hydrographic services.

Source: viadonau/Andi Bruckner

Gauge staff at a gauging site; sample water level at gauge: 95 cm

It has to be kept in mind that the water level measured at a water gauge does not allow for any conclusions about the actual water depth of a river to be made and hence about current fairway depths. This is due to the fact that the **gauge zero**, i.e. the lower end of a gauge staff or altitude of a gauge, does not correspond with the location of the riverbed. The gauge zero can lie above or below the medium riverbed level of a river section. In rivers, the flow of the current and the riverbed change fairly often and hence the gauge zero of a water gauge cannot be constantly realigned.

When assessing the currently available water depths within the fairway, boat masters refer to **gauges of reference**, which are relevant for certain sections of inland waterways. The water levels at the water gauge of reference are decisive for the draught loaded of vessels, for the passage heights under bridges and overhead lines as well as for restrictions on or suspension of navigation in periods of floods.

Reference water levels

The mean sea level measured at a gauging site of the nearest ocean coast serves as the reference for determining the absolute or geographic level of a gauge zero on the earth's surface, the so-called **absolute zero point.** Hence, the water gauges along the river Danube have different reference points: the North Sea (Germany), the Adriatic Sea (Austria, Croatia, Serbia), the Baltic Sea (Slovakia, Hungary) and the Black Sea (Bulgaria, Rumania, Moldova, Ukraine).

As the water level at a gauge changes continually, **reference water levels** or **characteristic water levels** have been defined in order to gain reference values, e.g. on the maintained depth of the fairway. Characteristic water levels are **statistical reference values for average water levels** which have been registered at a certain gauge over a longer period of time. The most important reference water levels for inland waterway transport are:

- **Low navigable water level** (LNWL)
- **Highest navigable water level** (HNWL)

If the highest navigable water level (HNWL) is reached or exceeded by over a certain degree, the authority responsible for the waterway section concerned may impose a temporary suspension of navigation for reasons of traffic safety.

Low navigable water level (LNWL) = the water level reached or exceeded at a Danube water gauge on an average of 94% of days in a year (i.e. on 343 days) over a reference period of several decades (excluding periods with ice).

Highest navigable water level (HNWL) = the water level reached or exceeded at a Danube water gauge on an average of 1% of days in a year (i.e. on 3.65 days) over a reference period of several years (excluding periods with ice).

Fairway and fairway channel

The term **fairway** refers to the part of an inland waterway that is navigable for shipping at a particular water level and that is marked by **fairway signs**. The **fairway channel** is the area of a body of inland water for which the waterway administration seeks adherence to certain fairway depths and fairway widths for navigation purposes. The fairway channel is therefore part of the fairway. A 'minimal' cross section is assumed on rivers in determining the cross-section of the channel, so its depth and width. It is derived from the 'most shallow' and 'narrowest' points of a certain river section at low water. For the Danube, the **fairway channel depth** determined for a 'minimal' cross section refers to the low navigable water level (LNWL). The **current fairway channel depth** can be calculated with the following formula:

Current water level at gauge of reference
+ Minimum fairway channel depth at LNWL
- LNWL value for gauge of reference
= Current minimum fairway channel depth

In order to provide navigation with sufficient fairways channel depths of natural waterways during periods of low water levels and enable cost-effective transport on a river even during such adverse water levels, **river engineering measures** may be taken. This usually involves the installation of **groynes** that keep the river's water yield in the fairway channel during low water levels. Groynes are structures which are normally made up of armour stones which are dumped into a certain area of the riverbed at a right angle or with a certain inclination. River engineering structures which are constructed parallel to a river's flow are called **training walls** and have the purpose of influencing the flow direction of a body of water and stabilising its cross section.

Source: viadonau

Declining groyne, i.e. adjusted to the river's flow direction, for river regulation at low water levels

The authorities and organisations responsible for maintaining a waterway aim to keep fairways at a constant minimum depth, e.g. by conservational dredging measures in the fairway. These so-called **minimum fairway channel depths** are geared to low navigable water level (LNWL) as a statistical reference value for the water level.

For more information on the interdependency of available fairway channel depths and the cost-effectiveness of Danube navigation, refer to the section 'Business management and legal aspects' in the chapter 'Logistics solutions: The market for Danube navigation'.

As there are **no guaranteed minimum fairway channel depths** at LNWL on the Danube (with the exception of the Bavarian section of the Danube in Germany), boat masters and shipping operators have to plan their journeys according to the fairway channel depths which are currently available at the most shallow stretches of the waterway or according to the admissible maximum draught loaded (= draught of a vessel when stationary) as foreseen by waterway police regulations.

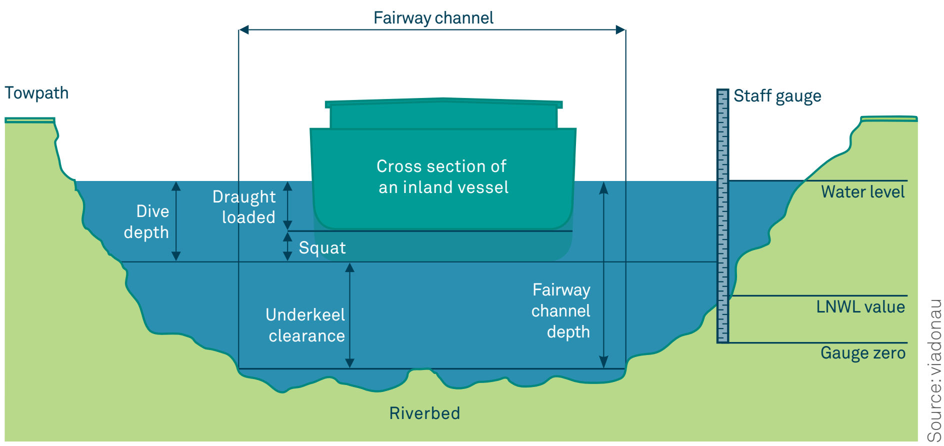
The Romanian section of the Danube between Brăila and Sulina is also termed the **maritime Danube** as this section is also navigable by river-sea vessels and sea-going vessels. 170 kilometres long, this river section is maintained by the Romanian River Administration of the Lower Danube for vessels with a maximum draught of 7.32 metres. Beyond this, the **Kilia/Bystroe arm**, which is not subject to the Belgrade Convention and which falls under the Ukrainian waterway administration, is navigable by river-sea vessels and sea-going vessels.

Draught loaded, squat and underkeel clearance

Fairway depths available in the fairway channel 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 usable for navigation companies have a decisive influence on the cost-effectiveness of inland waterway transport.

Immersion depth = draught loaded ($v_{vessel} = 0$) + squat ($v_{vessel} > 0$)

In calculating the potential draught loaded of a vessel on the basis of current fairway or fairway channel depths, the **dynamic squat** as well as an appropriate safety clearance to the riverbed, the so-called **underkeel clearance**, have to be considered in order to prevent groundings of cargo vessels in motion. The **immersion depth** of a ship equals the sum of its draught loaded (loaded vessel in stasis; velocity v = 0) and its squat (loaded vessel in motion; velocity v > 0).



Parameters of fairway channel (schematic presentation)

Squat refers to the level to which a ship sinks while it is in motion compared to its stationary condition on waterways with a limited cross section (i.e. rivers and canals). A loaded vessel has a squat within a range of about 20 to 40 centimetres. As the squat of a vessel is continually changing according to the different cross sections of a river and the different velocities of a vessel, the boatmaster should not calculate the safety clearance between the riverbed and the bottom of the vessel too tightly when determining the draught loaded of his vessel.

This safety clearance is termed **underkeel clearance** and is defined as the distance between the bottom of a vessel in motion and the highest point of the riverbed. Underkeel clearance should not be less than 20 centimetres for a riverbed made of gravel or 30 centimetres for a rocky bed in order to prevent damage to the ship's propeller and/or its bottom.

Underkeel clearance = fairway channel depth – (draught loaded + squat)

Fairway signs

The width and the course of the fairway are marked by internationally standardised **fairway signs** such as buoys or traffic signs ashore.

Resolutions of the Working Group on Inland Water Transport of the UNECE's Inland Transport Committee: www.unece.org/trans/main/sc3/sc3res.html

In 1985, the Inland Transport Committee of the United Nations Economic Commission for Europe (UNECE) adopted the **European Code for Inland Waterways** (CEVNI) in Resolution No 24 (United Nations Economic Commission for Europe, 2015). Among other things, CEVNI specifies standardisation of the fairway signs at European level and is fleshed out by the **Guidelines for Waterway Signs and Marking** (United Nations Economic Commission for Europe, 2016a).

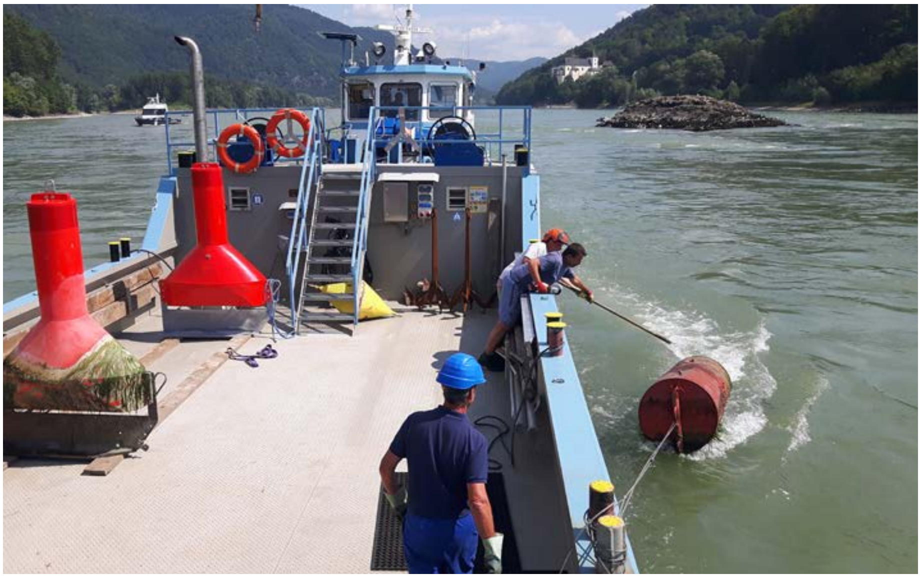
In regard to the marking of fairway limits in the waterway, the right side of the fairway is indicated by red, cylindrical fairway signs, while the left side is delimited by green, cone-shaped signs. The terms 'right side' and 'left side' of the waterway or fairway or the fairway channel, apply to an observer looking downstream, i.e. in the direction in which the water is flowing. Buoys (with or without red or green lights), floats or floating rods can be used as **floating fairway signs**. They must be fitted with a cylindrical or conical top mark if their own shape is not cylindrical or conical.

Floating fairway signs must be equipped with **radar reflectors** to ensure that they show up on the ship radar. They may be the aforementioned top marks or separate signs that are attached on or in the fairway signs.

Together with the floating signs on the waterway, fixed **fairway signs on land** indicate the course of the fairway relative to the banks and show the points at which the fairway comes closer to either of the banks. Square boards, either with or without a red or green light, are used as land-side fairway signs.

Red and green **rhythmic lights** on the fairway signs help to improve transport safety during poor visibility and at night. Rhythmic lights emit light of constant intensity and colour with a certain, recurring succession of light signals and interruptions.

The Danube Commission adopted the UNECE provisions for the Danube waterway in its **Basic Rules of Navigation on the Danube (DFND)** (Danube Commission, 2010) and in the accompanying **Instruction for installation of fairway signs on the Danube** (Danube Commission, 2015).



Source: viadonau/Thomas Hartl

Manipulation of a red buoy to indicate the right-hand limit of the fairway on the Austrian section of the Danube

Landing sites

Landing sites are specially marked areas on the banks of a waterway at which vessels or floating bodies can berth. There may be many reasons why a ship would have to interrupt its travel and berth at a landing site. Loading and unloading of cargo, embarking or disembarking of passengers, bunkering of fuel, adherence to rest periods, crew changes, provisioning, visits to doctors or the authorities, repairs, health and technical emergencies etc. However, landing sites are often reserved for certain vehicles only (e.g. landings for small vessels, fuel landings, fire brigade landings) or are used for a special function (transhipment sites, waiting berths, emergency berths). A distinction can also be made between public and non-public landing sites.

Landing sites are marked by **navigation signs** that indicate the direction of the landing site (relative to the navigation sign), its length, berthing rules and possibly the maximum berthing period or vehicles that are exclusively permitted to use the landing site, among other things.

The banks of a landing site are structurally designed either in **slanted shoring** (riprap) or **vertical shoring** (wall or sheet piling). Vertical shoring enables direct berthing close to the bank and increases safety when departing or boarding the vessel. Established alternatives to vertical shoring include dolphins or pontoons that are equipped with additional walkways that enable the crew to board or disembark safely.

Some landings are equipped with **additional facilities** for navigation, including the supply of shore-side power and drinking water, waste disposal, places to deposit a car or lighting.

Source: viadonau

Cargo vessel at a Danube landing site

River power plants and lock facilities

Barrages, i.e. facilities which impound a river with the aim of regulating its water levels, are often created in the form of **river power plants**, which convert the power of the flowing water into electrical energy. In this process they make use of the incline created by impounding the water between the water upstream and downstream of the power plant (headwater and tailwater).

A river power plant usually comprises of one or several **powerhouses**, the **weir** and the **lock** with one or more lock chambers. Locks enable inland vessels to negotiate the differences in height between the impounded river upstream of a power plant and the flowing river downstream of a power plant.

The most common type of lock on European rivers and canals is the **chamber lock** whereby the headwater and the tailwater are connected via a lock chamber which can be sealed off at both ends. When the lock gates are closed, the water level in the lock chamber is either raised to the headwater level (admission of water from the reservoir) or lowered to the tailwater level (release of water into the section downstream of the power plant). No pumps are required for the admission and release of the water.

Depending on the direction in which a vessel passes through a lock, the terms used are **upstream locking** (from tailwater to headwater) or **downstream locking** (from headwater to tailwater). Once a vessel which needs to pass through a lock has been announced via radio, the locking is carried out by the **lock manager**. A locking operation takes approximately 40 minutes, about half of which is required to navigate the vessel into and out of a lock chamber.

Source: viadonau

Lock facility at the river power plant at Vienna-Freudenau (river-km 1,921.05)

The fairway depth in a lock chamber is determined by the **depth at the pointing sill** – the distance between the surface of the water and the pointing sill, i.e. the threshold of a lock gate which forms a watertight seal with the gate to avoid drainage of the lock chamber.

Special protective devices protect the lock gates from damage caused by vessels.

Stop logs serve to seal off lock chambers from headwater and tailwater in order to drain lock chambers. They are used mainly for reasons of **lock overhaul**, i.e. for maintenance work or for the replacement of lock components.

There are a total of **18 river power plants** on the Danube, with 16 of these power plants located on the Upper Danube due to the high gradient of the river between Kelheim and Gönyű. 14 of the 18 lock facilities on the Danube have **two lock chambers**, thus enabling the simultaneous locking of vessels sailing upstream and downstream.

The lock facilities downstream of Regensburg all feature a minimum **utilisable length** of 226 metres and a **width** of 24 metres which enables locking of convoys made up of at least two pushed lighters which are coupled in parallel.

No.	Lock/power plant	Country	River-km	Lock chambers		
				Length (m)	Width (m)	Number
1	Bad Abbach	DE	2,397.17	190.00	12.00	1
2	Regensburg	DE	2,379.68	190.00	12.00	1
3	Geisling	DE	2,354.29	230.00	24.00	1
4	Straubing	DE	2,327.72	230.00	24.00	1
5	Kachlet	DE	2,230.60	226.50	24.00	2
6	Jochenstein	DE/AT	2,203.20	227.00	24.00	2
7	Aschach	AT	2,162.80	230.00	24.00	2
8	Ottensheim-Wilhering	AT	2,147.04	230.00	24.00	2
9	Abwinden-Asten	AT	2,119.75	230.00	24.00	2
10	Wallsee-Mitterkirchen	AT	2,095.74	230.00	24.00	2
11	Ybbs-Persenbeug	AT	2,060.29	230.00	24.00	2
12	Melk	AT	2,038.10	230.00	24.00	2
13	Altenwörth	AT	1,980.53	230.00	24.00	2
14	Greifenstein	AT	1,949.37	230.00	24.00	2
15	Freudenau	AT	1,921.20	275.00	24.00	2
16	Gabčíkovo	SK	1,819.42	275.00	34.00	2
17	Đerdap/Porțile de Fier I	RS/RO	942.90	310.00*	34.00	2
18	Đerdap/Porțile de Fier II	RS/RO	863.70 862.85	310.00	34.00	2

*The lock Đerdap / Porțile de Fier I consists of two consecutive lock chambers which require two-stage lockage

Source: viadonau

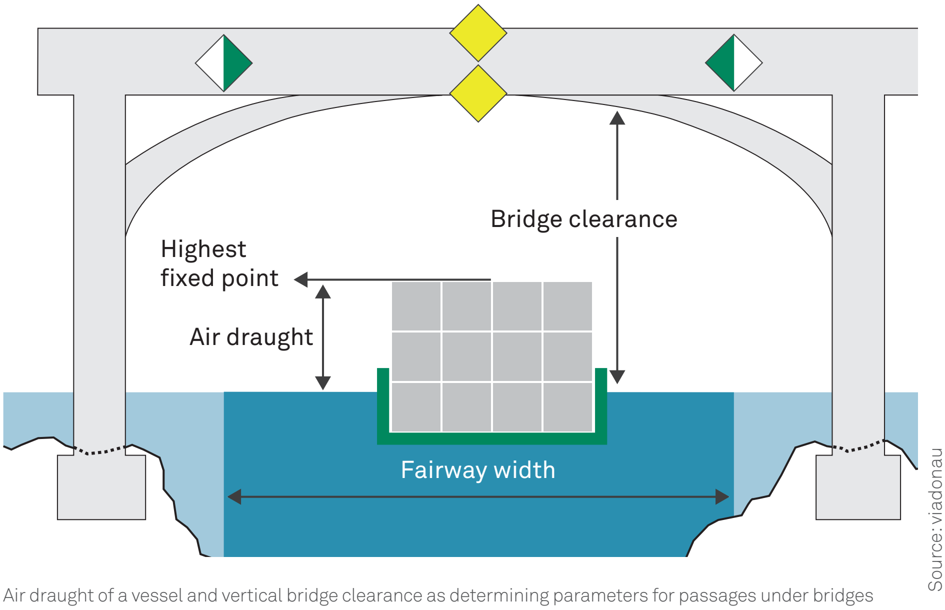
Lock facilities along the Danube

Bridges

Bridges can span a waterway, a port entrance or a river power plant and hence a lock facility. On free-flowing, i.e. unimpounded river sections, water levels can be subject to considerable fluctuations which influence the potential passage under bridges at high water levels.

Depending on the distances between the individual bridge pillars there will be one or more – in most cases two – **openings for passage** of vessels. If a bridge has two openings for passage which are dedicated for navigation purposes, one is generally used for upstream traffic and the other for downstream traffic. Suitable **navigation signs** that are mounted directly on the bridge indicate whether the passage through a bridge opening is permitted or forbidden.

Whether a vessel can pass under a bridge depends on the **vertical bridge clearance** above the water level and on the **air draught of the vessel**. The air draught of a vessel is the vertical distance between the waterline and the highest fixed point of a vessel once movable parts such as masts, radar devices or the steering house have been removed or lowered. The air draught of a vessel can be reduced by **ballasting** the vessel. For this purpose, ballast water is pumped into the ballast tanks or solid ballast is loaded.



Air draught of a vessel and vertical bridge clearance as determining parameters for passages under bridges

Apart from the height of the bridge openings and a vessel's air draught, the **bridge profile** is another factor which determines whether a vessel is able to pass under a bridge. For sloped or arch-shaped bridges, not only a vertical but also a sufficiently dimensioned **horizontal safety clearance** must be ensured. As the figures indicating the height and width of an opening for passage below a bridge always refer to the entire width of the fairway, the clearance below the crest of arch-shaped bridges, i.e. below the centre of the bridge, is higher than at the limits of the fairway.

On free-flowing sections of rivers, **vertical bridge clearance** is indicated in relation to the **highest navigable water level** (HNWL), whereby the indicated passage height corresponds to the distance in metres between the lowest point of the lower edge of the bridge over the entire fairway width and the highest navigable water level. The **width of the fairway** below a bridge is indicated in relation to **low navigable water level** (LNWL). In river sections regulated by dams, the maximum impounded water level serves as the reference value both for the vertical and the horizontal bridge clearance. The reference level on artificial canals is the upper operational water level.

Between **Kelheim** and **Sulina**, a total of **129 bridges** span the international Danube waterway. Of these 129 Danube bridges, 21 are bridges over locks and weirs.
By far the greatest frequency of bridges is found on the **Upper Danube** (89 bridges): 41 bridges span the German section of the Danube, 41 the Austrian and seven the Slovakian or Hungarian sections of the Danube. On the **Central Danube** there are a total of 33 bridges; on the **Lower Danube** there are only seven.

Fairway maintenance

The necessary works for the maintenance of the fairway on natural waterways such as rivers 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.

The **transport of sediments** (e.g. gravel or sand) is an important dynamic process in free-flowing sections of rivers, especially in periods with higher water levels and the corresponding higher flow velocities of the river. Along with the respective discharge of the river, this transportation of sediment leads to **continuous change in the morphology of the riverbed**, either in the form of sedimentation or erosion.

In shallow areas of the river this continuous change of the riverbed can lead to restrictions for navigation with regard to the minimum fairway parameters (depth and width) to be provided by waterway administrations, i.e. reduced depths and widths of the fairway.

Legal and strategic framework

The overriding aim with regard to the maintenance and optimisation of waterway infrastructure by the Danube riparian states is the **establishment and year-round provision of internationally harmonised fairway parameters**.

The recommended minimum fairway parameters for European waterways of international importance – including the Danube – are listed in the **European Agreement on Main Inland Waterways of International Importance** (AGN) (United Nations Economic Commission for Europe, 2010). With regard to the fairway depths to be provided by waterway administrations, the AGN makes the following provisions: On waterways with fluctuating water levels the value **of 2.5 metres minimum draught loaded of vessels** should be reached or exceeded on 240 days on average per year. However, for upstream sections of natural rivers characterised by frequently fluctuating water levels due to weather conditions (e.g. on the Upper Danube), it is recommended to refer to a period of at least 300 days on average per year.

Based on the **Convention Regarding the Regime of Navigation on the Danube**, which was signed in Belgrade on 18 August 1948 ('Belgrade Convention'), the Danube Commission recommended the following fairway parameters for the Danube waterway: **2.5 m minimum fairway depth** (1988), respectively **2.5 m minimum draught loaded of vessels** (2013) below low navigation water level (LNWL) (i.e. on 343 days on average per year) on free- flowing sections and a minimum fairway width of between 100 and 180 metres, dependent on the specific characteristics of the river section concerned (Commission du Danube, 1988 or Danube Commission, 2011).

On 7 June 2012, the transport ministers of the Danube riparian states met for the first time at the European Union's Council of Transport Ministers in Luxemburg to agree on a **Declaration on effective waterway infrastructure maintenance on the Danube and its navigable tributaries**. The riparian states are committed to maintaining adequate fairway parameters for good navigational status according to the provisions of the 'Belgrade Convention' and – for those countries who have ratified it – the AGN.

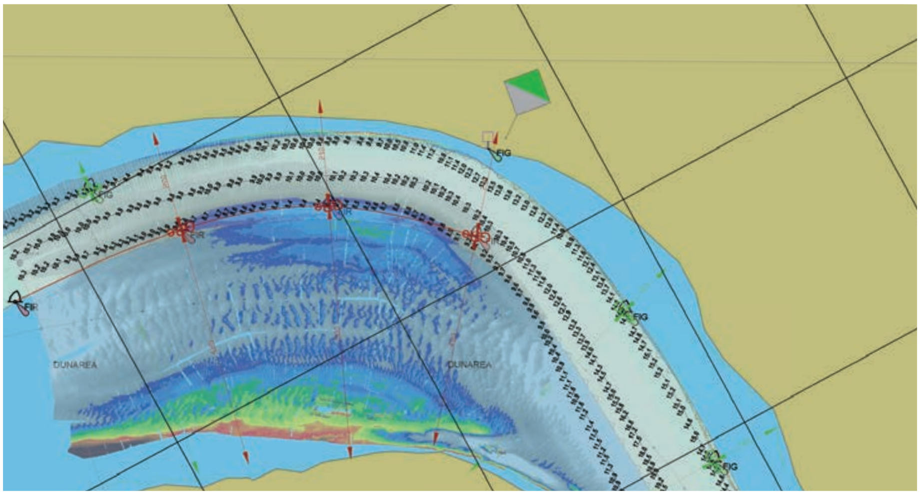
Information about the Master Plan and its monitoring: www.danube-navigation.eu/documents-for-download

FAIRway Danube project: www.fairwaydanube.eu

Further information on the EU Strategy for the Danube Region and on the EU's trans-European transport network is found in the chapter 'Objectives and Strategies' of this manual.

Clear guidelines to achieve the targets enshrined in the declaration were prepared in 2014 by Priority Area 1a – Inland Waterways – within the EU Strategy for the Danube Region in a central document, the **Fairway Rehabilitation and Maintenance Master Plan for the Danube and its Navigable Tributaries**. The Master Plan indicates the shallow sections along the Danube that are critical for navigation and describes the medium-term measures that are necessary in the area of waterway management in order to alleviate these shallow sections. The Master Plan was jointly adopted by the majority of the Danube transport ministers in 2014, providing significant political backing. The transport ministers confirmed once again in 2016 and 2018 that they would provide the necessary funding at national level. Implementation of the Master Plan is reviewed twice each year.

As a flanking measure, the transnational **FAIRway Danube** project, which is co-funded by the EU, will carry out key aspects of the Master Plan by 2021 and in doing so will make a significant contribution to its implementation.



Source: Administrația Fluvială a Dunării de Jos

Bathymetric survey of the maritime Danube stretch in Romania near Tulcea

Fairway maintenance cycle

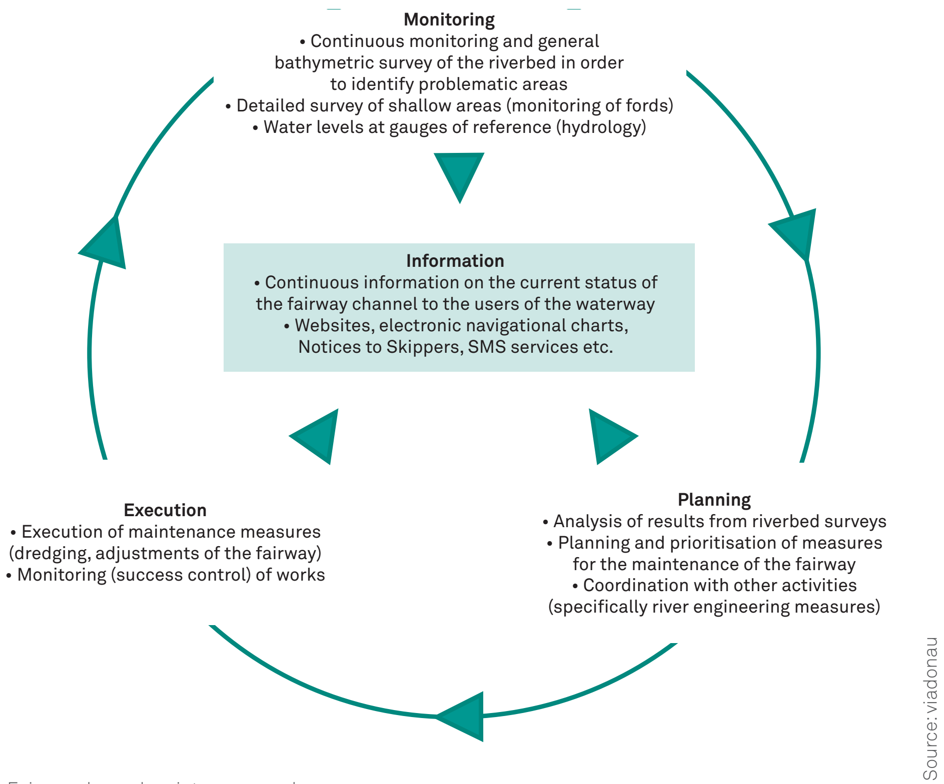
In the case that the minimum fairway parameters are not achieved, the responsible waterway administration is obliged to take suitable measures in order to re-establish them. This is generally accomplished by **dredging shallow areas** (fords) within the fairway. Dredging is an excavation operation with the purpose of removing bottom sediments (sand and gravel) and disposing of them at a different location in the river in due consideration of ecological aspects.

Where recurring dredging is necessary at certain fords, it is possible to implement **hydraulic engineering optimisation measures** in order to ensure adherence to the defined fairway parameters for navigation. Doing so significantly reduces ongoing dredging operations and improves availability of the fairway.

Dredging and hydraulic engineering measures require predictive planning based on the results of regular **bathymetric surveys** and a subsequent review (success monitoring) of the work by the competent waterway administration body.

Given that the **measures** to maintain the fairway are **recurring and interdependent**, it is reasonable to speak of a fairway channel maintenance cycle. Among the most important tasks of this cycle are:

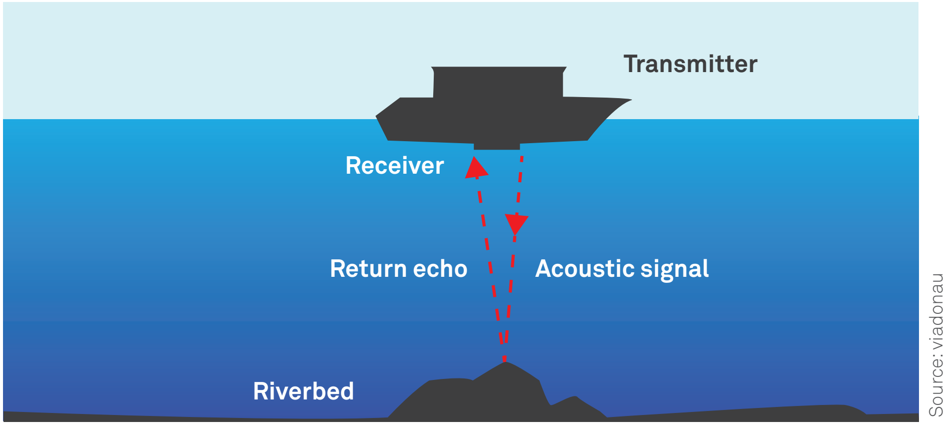
- Regular bathymetric surveys of the riverbed in order to identify problematic areas in the fairway channel (reduced depth and widths)
- Planning and prioritisation of necessary interventions (dredging measures, realignment of the fairway channel, traffic management) based on the analysis of up-to-date bathymetric surveys
- Execution of maintenance works (mainly dredging measures, including success monitoring)
- Provision of continuous and target group-specific information on the current state of the fairway channel to the users of the waterway



Fairway channel maintenance cycle

Surveying of the riverbed

The continuous bathymetric surveying of the riverbed is one of the basic tasks of a waterway administration in order to carry out fairway maintenance measures. Bathymetric survey is conducted on so-called **survey vessels** which are equipped with specific **survey equipment**.



Schematic mode of operation of an echo sounder

The most important device for bathymetric surveying of the riverbed is an **echo sounder** which uses sonar technology for the measurement of underwater physical and biological components. Sound pulses are directed from the water's surface vertically down to measure the distance to the riverbed by means of sound waves. The transmit-receive cycle is rapidly repeated at a rate of milliseconds. The continuous recording of water depths below the vessel yields high-resolution depth measurements along the survey track. The distance is measured by multiplying half the time from the signal's outgoing pulse to its return by the speed of sound in the water, which is approximately 1.5 km/sec.

The two main bathymetric systems for bathymetric surveying which are based on the technology of echo sounding are the single-beam and the multi-beam methods.

Single-beam bathymetric systems are generally configured with a transducer mounted to the hull or the side of a survey vessel. A sonar transducer turns an electrical signal into sound (transmitter) and converts sonar pulses back into electrical signals (receiver). Survey vessels using the single-beam technology can only measure water depths below their own survey track, i.e. directly beneath the vessel, thus creating cross or length profiles for the water depths of a river.

Accordingly, areas in between the recorded profiles are not surveyed, but in order to display survey results on a map, water depths for these areas are calculated on the basis of a mathematical interpolation method. Consequently, single-beam technology cannot ensure a full coverage of the current morphology of the riverbed. Waterway administrations generally use the single-beam technology to gain a quick overview on the general morphology of river stretches.

In order to obtain full coverage of a riverbed, **multi-beam bathymetric systems** are used. The multi-beam sonar system has a single transducer, or a pair of transducers, which continually transmits numerous sonar beams in a swathe or fan-shaped signal pattern to the riverbed. This makes multi-beam systems ideal for the rapid mapping of large areas. In addition, and in contrast to single-beam technology, multi-beam bathymetry yields 100% coverage of the morphology of a riverbed, i.e. there are no data gaps between cross or length profiles produced by single-beam bathymetry. Unfortunately, multi-beam surveys are more time-consuming and also more complex than single-beam surveys. Waterway administrations use the multi-beam technology as a basis for the planning and monitoring of dredging works as well as for other complex tasks such as searching for sunken objects or research activities.

Source: viadonau/Andi Bruckner

Multi-beam bathymetric survey on the free-flowing section of the Danube east of Vienna by via donau – Österreichische Wasserstraßen-Gesellschaft mbH

Maintenance dredging works

On the basis of the results of a bathymetric survey of the riverbed, shallow areas within the fairway which need to be dredged can be identified. Waterway administrations either carry out dredging works themselves or assign specialised hydraulic engineering to the task.

The essential questions in this respect are: How much material (measured in m^3) needs to be dredged at which location? At which location shall the dredged material be deposited in the river? The latter question has both an economic aspect (distance between dredging site and disposal area) as well as an ecologic aspect: Where is the best place to dispose of the dredged material in terms of environmental impact?

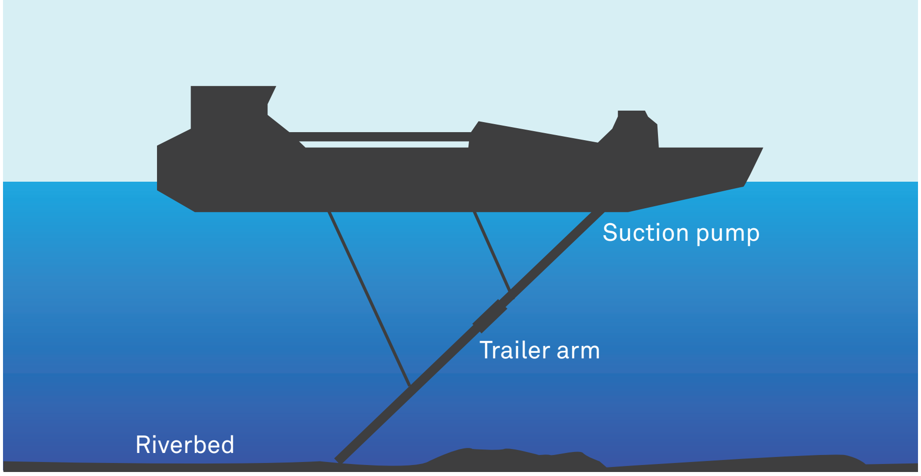
In general, the selection of the dredging equipment to be used for a specific measure is based on the characteristics of the dredging task. The equipment used on the Danube waterway is described in greater detail in the following.

On the Upper Danube from Germany to Hungary, where the riverbed generally consists of coarse material (gravel or rocky material), the dredging equipment usually used is backhoe dredgers in combination with hopper barges. A backhoe dredger consists of a hydraulic crane which is mounted on a spud pontoon. The crane excavates the material and loads it onto a hopper barge for transportation. Hopper barges have a bottom equipped with doors which can be opened to deposit the dredged material at the disposal point. These non-motorised vessels are moved forward by pushers and need minimum water depths of approximately two metres. Backhoe dredgers can dredge a wide range of different materials (from silt to soft rock), but their output level is limited. This dredger type is very convenient for accurate dredging such as the removal of local shallow areas.

Source: viadonau

Dredging works with backhoe dredger in combination with hopper barges on the free-flowing section between Vienna and Bratislava

Trailing suction hopper dredgers are well suited to dredging soft soil (silt or sand) but require sufficient water depths, i.e. a minimum of five metres. This dredging equipment is especially suitable for the Lower Danube on the Bulgarian and Romanian stretches of the river, where the riverbed consists mainly of silt or sand. Trailing suction hopper dredgers are vessels which are equipped with a suction pipe which acts like a huge 'vacuum cleaner' on the riverbed. The excavated material is sucked on board and collected in the hold of the vessel. Once it is fully loaded, the vessel travels to its destination. Arriving there, the doors in the base of the hold are opened and the excavated material is deposited on the riverbed. This type of dredger does not need anchors and is also very convenient for carrying out maintenance dredging works, provided that a disposal site can be found in the river at a reasonable distance.



Source: viadonau

Schematic view of a trailing suction hopper dredger

Hydraulic engineering optimisation of critical ford areas

It is advisable to use hydraulic engineering measures to optimise shallow areas and fords that require frequent dredging. Firstly this significantly reduces the regularity of necessary maintenance dredging and the associated, ongoing costs for the waterway operators, while secondly ensuring permanent adherence to the fairway parameters that are required for navigation.

These hydraulic engineering measures must consider the specific situation at the shallow section and make best possible use of existing water structures like **groynes and training walls** to keep the extent of intervention as low as possible. In addition, **ecological optimisation measures** should also be considered as early as the planning phase, for instance the construction of subsurface channels close to the banks. Besides classic elements within hydraulic engineering (groynes and training walls), alternative approaches such as **island landfills** can also produce the desired effects.

Source: viadonau

Hydraulic engineering optimisation on the Austrian Danube: Extension of current groynes near Bad Deutsch-Altenburg and Treuschütt on the free-flowing section between Vienna and Bratislava

Source: viadonau

Hydraulic engineering optimisation on the Austrian Danube: Island landfill in the Rote Werd ford of the free-flowing section between Vienna and Bratislava

Digitalisation and waterway infrastructure

In regard to the waterway infrastructure, a clear distinction can be made between digitalisation measures that are intended to optimise the physical waterway infrastructure (assets) and traffic management ('digital infrastructure'), and those measures that relate to information concerning the current availability (transport route) and current use of the infrastructure (ongoing transports) ('digital information services'):

Digital infrastructure (main users: infrastructure operators): infrastructure (asset) management systems (maintenance and expansion of the waterway infrastructure, bed-load management), automation and remote control of lock and weir facilities, lock management (optimised chamber utilisation), marking of waterways (remote monitoring of shore-side and water-borne fairway signs), generation of basic data (bathymetric survey, gauges), compilation and visualisation of the data in geographic information systems.

Digital information services (main users: boatmasters, fleet operators, logistics specialists): Fairway information services as part of the River Information Services (water levels, information on shallow sections, route and lock availability, vertical clearance under bridges, Notices to Skippers), digital Aids to Navigation (virtual fairway signs in electronic navigational charts), berth occupation and berth booking systems (current availability).

River Information Services are described in their own chapter in this manual.

The following provides a more detailed description of the services and tools that are already in operation along the Danube waterway.

Digital asset management

Asset management systems for waterways enable an integrative view of waterway infrastructure management or its parts and sections (e.g. fairway/fairway channel, river structures such as groynes or training walls, landing sites, locks or bridges). The provisioning of **asset management software**, combined with a broad variety of basic data, can be used, through the application of big data methods, to obtain profound and visually processed decision-making support for maintenance and improvement measures on waterways at the push of a button. Basic data includes riverbed images, information on the location and dimensions of the fairway or the fairway channel, the positions of water-side marks and signs, the condition of structures (e.g. groynes, training walls, landing sites, locks), current and historical gauge data, transport flows etc. The matching processes can be digitally modelled within operative planning and implementation of specific constructional measures and hence optimise and provide an objective foundation for the budgeting, impact assessment, monitoring and documentation of individual measures.

Holistic asset management systems for waterways remain in their nascent stages at European and global level. The feasibility of a cross-border asset management system and the underlying system elements was examined for the international Danube waterway within the framework of a study conducted as part of the EU-funded 'Network of Danube Waterway Administrations – data & user orientation' (NEWADA duo) project (Hoffmann et al., 2014).

The waterway monitoring system WAMOS is currently being established in several Danube states within the framework of the EU-funded 'FAIRway' project and on the basis of this study and the WAMS waterway asset management system (see below), which has already been implemented in Austria. This system aims to compile within a Danube-wide database a minimal set of waterway infrastructure data (bathymetric survey, water levels, infrastructure measures) originating from national waterway (asset) management systems.

Waterway asset management in Austria

The waterway asset management system WAMS was created in a multi-year research project conducted in cooperation between viadonau as the waterway infrastructure operator and the Technical University Vienna; its purpose is to manage the infrastructure on the Austrian section of the Danube. In operation at viadonau since 2015, the software delivers improved decision-making assistance for efficient and ecologically optimised maintenance of the waterway. WAMS has a modular structure and includes the following functions and features, among others:

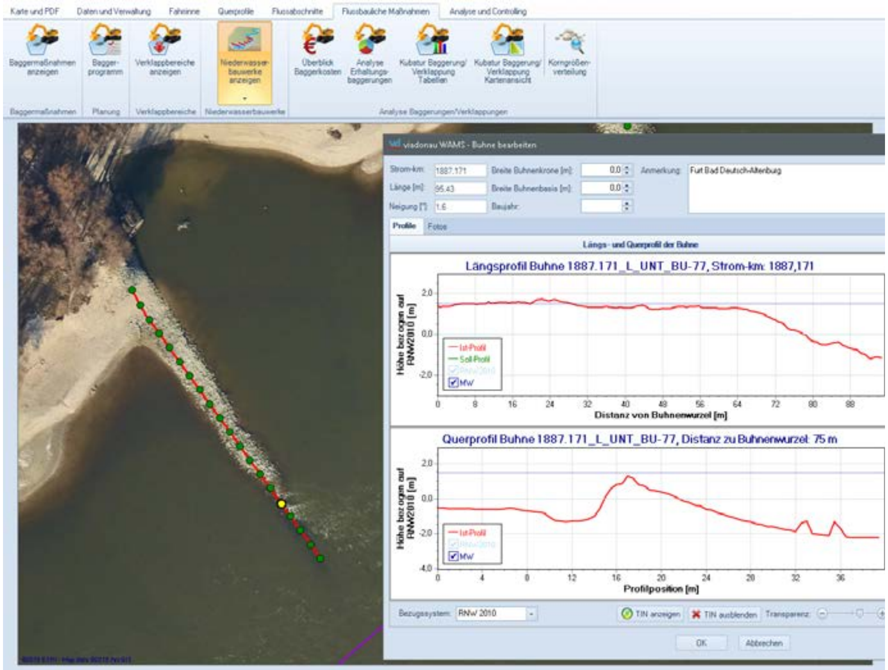
- Central waterway database for the management of big data, including a graphic user interface; the database brings together basic infrastructural data such as riverbed images and water levels and permits, among other things, the analysis of fairway channel availability or the evaluation of sedimentation and erosion in freely definable sections of the waterway.

- Process management for dredging works: Maintenance measures in the fairway channel can be planned and optimised systematically using the software; their implementation and results can then be monitored and visualised in a transparent and comprehensible form.

- Support for optimisation of the bedload cycle toward a holistic system of sediment management to reduce riverbed erosion and to optimise maintenance: Comprehensive documentation on dredging and dumping in the area of the free-flowing section east of Vienna; visualisation of the quantities and the ecological impact of dumping bedload further upstream.

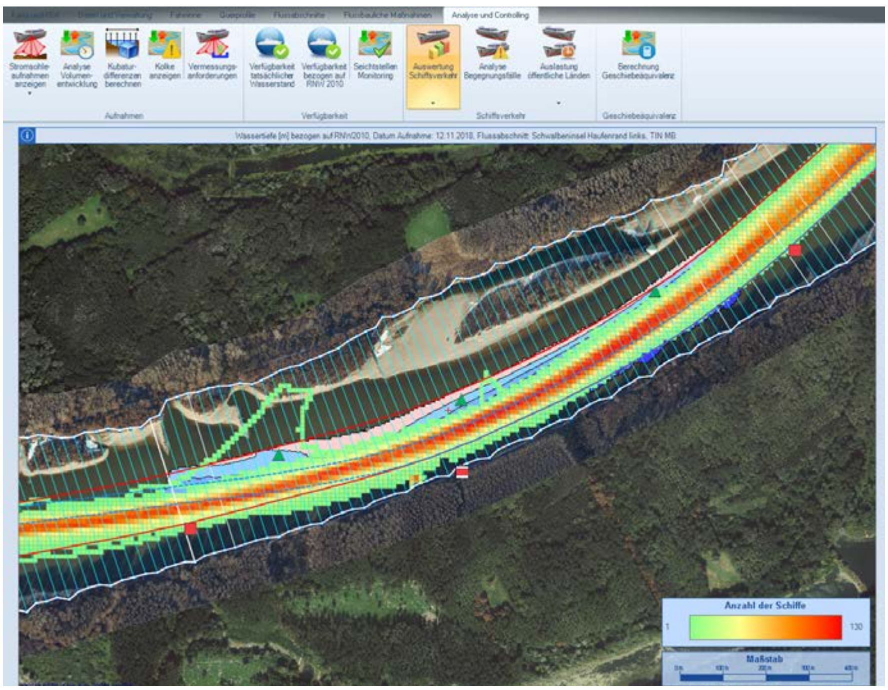
- Analysis and functional assessment of the low water regulating structures over their life time: The precise location and condition of the individual structures are mapped precisely based on aerial images and multi-beam surveys and then visualised in the WAMS system; this can be used to derive any necessary maintenance work required on the structures.

- Consideration of the traffic flows on any definable sections for the optimisation of infrastructure based on fairway channel utilisation: Visualisation of the actual vessel tracks (by means of so-called 'heat maps') and combination with infrastructure data (bathymetric surveys) to enable optimisation of the fairway channel trajectory and possible dredging measures.



Presentation of the cross and length profiles of a groyne in WAMS; the elevation points are obtained from laser scanning flights

Source: viadonau



Heat map presentation of vessel tracks in WAMS, obtained from around Schwalbeninsel on the free-flowing section between Vienna and Bratislava

Source: viadonau

Remote monitoring of fairway signs

Digitally-assisted monitoring of water and shore-side fairway signs such as fairway buoys with or without a rhytmic light or rhytmic lights on land enable continuous tracking of the correct position and functions of these traffic signs. Common technologies used for remote monitoring on waterways are GPS (satellite positioning), satellite communication (e.g. 'Globalstar') or the Automatic Identification System (AIS) by River Information Services.

Positional changes of **floating fairway signs** are monitored. For instance, a notification is sent if a fairway buoy moves beyond a defined limit (e.g. due to deviation or collision with a vehicle). This notification allows the competent waterway authorities to respond in good time and restore the proper state of the sign.

For **water or shore-side rhythmic lights** remote monitoring can also be used to track the lamp functions (condition, rhythm/flashing frequency, light intensity), current power supply (battery voltage) and ambient temperature.

Virtual fairway signs – known as 'virtual AtoNs (Aids to Navigation)' – are already used in the maritime sector. This involves sending icons of digital fairway signs to the boatmaster by AIS; they are then displayed on an electronic navigation chart on board, without the signs being physically present. There are also potential uses for this technology within inland navigation, for instance to ensure timely designation of hazardous areas (e.g. new shallow sections due to sediment relocation) or temporary traffic bottlenecks (e.g. around accidents). Naturally, it will only be possible to use virtual fairway signs if suitable display devices and current charts are available on the vessels themselves.

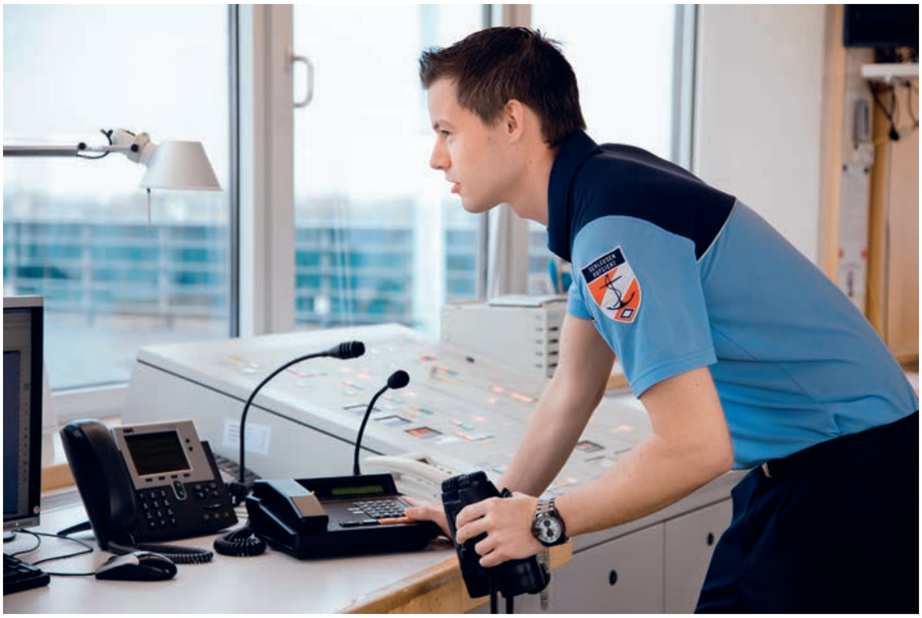

Source: viadonau/Raimund Appel, Thomas Hartl

Use of remote monitoring technologies on plastic buoys of the type B7 (without light) and LT B7 (with light); on the left: monitoring using Globalstar (satellite); on the right: monitoring using AIS

Digitally-assisted lock management

Locks constitute bottlenecks for inland navigation as the bundling of vessel traffic and the time-intensive process of locking delay the journey. Waiting times can be expected by vessels particularly before lock facilities, as currently no long-term advance notification of a vessel's arrival at a lock is possible. In the past, boatmasters have only been able to register for the locking process when they are already in the proximity of the lock facility due to the short radio range. Therefore, vessels arriving at the lock will be handled according to the principle of 'first come, first served' (the only exceptions are liner services, which are given priority in some countries).

The main purpose of a lock management system for inland navigation is to optimise traffic flows by making locking procedures more efficient and plannable. River Information Services (RIS) support navigation and lock operators in their daily tasks.



Source: viadonau/Pilo Pichler

Lock management at the lock Freudenau near Vienna

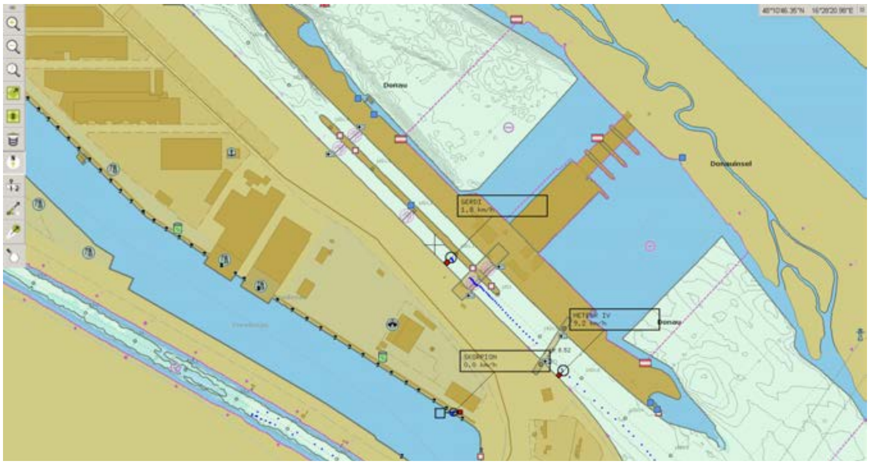
Before admission to European inland waterways, inland vessels have to undergo a technical inspection. The results of which are recorded in a central vessel database.

Lock management with RIS in Austria

The RIS systems to support lock management on the Austrian Danube consist of two main components:

- electronic traffic situation image from the DoRIS system
- electronic lock journal

There is also a connection to the European Hull Database and to the electronic reporting system for hazardous goods.

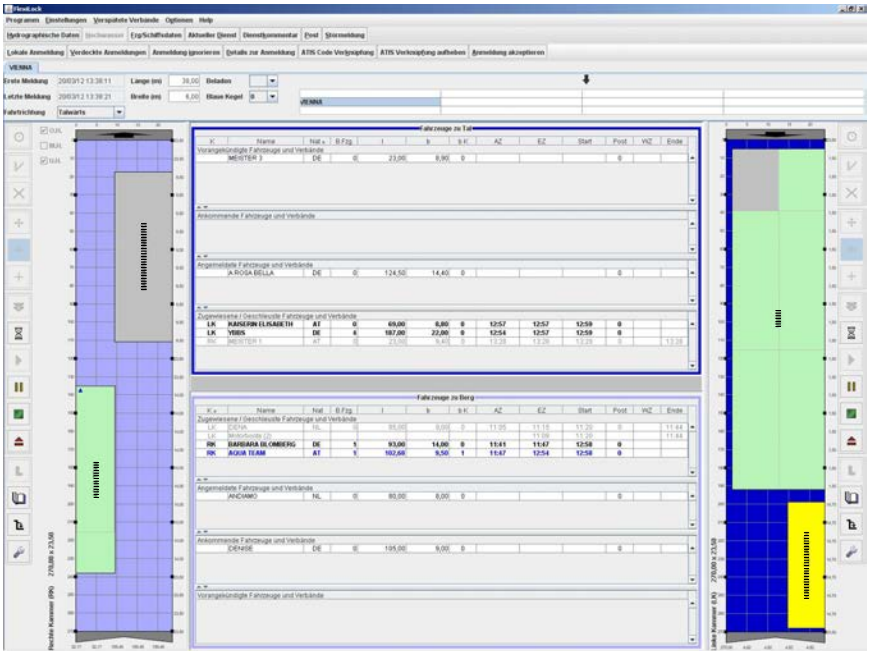


Source: viadonau

Visualisation of vessel traffic in the immediate proximity of a lock on the Electronic Navigational Chart

The **AIS (Automatic Identification System)**, which provides seamless geo-positioning of vessels, is used for the planning of locking and the identification of the optimum time to enter the lock. This enables optimised planning of locking cycles, the avoidance of waiting periods and a reduction in empty lock cycles. At the same time, vessels can send timely notification and can optimise their speed to reduce fuel consumption and costs where possible.

An **electronic lock journal** was introduced at the Austrian Danube locks. This system largely enables automated planning and documentation of all services at the lock.



Source: viadonau

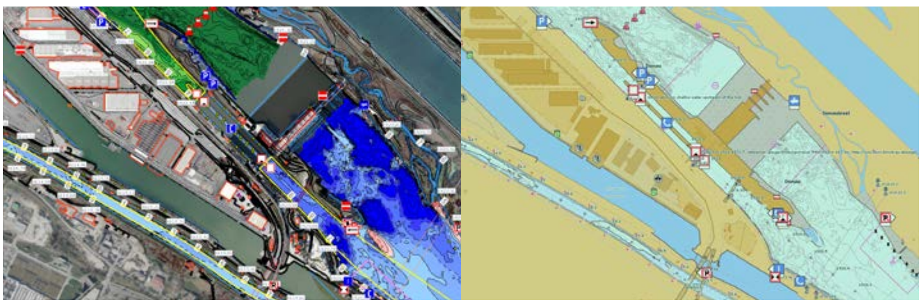
User interface for the electronic lock journal

Fairway Information Services

So-called **Fairway Information Services** (FIS) provide current information on the navigability of waterways and therefore support boatmasters, fleet operators and other waterway users in the planning, monitoring and execution of inland waterway transport.

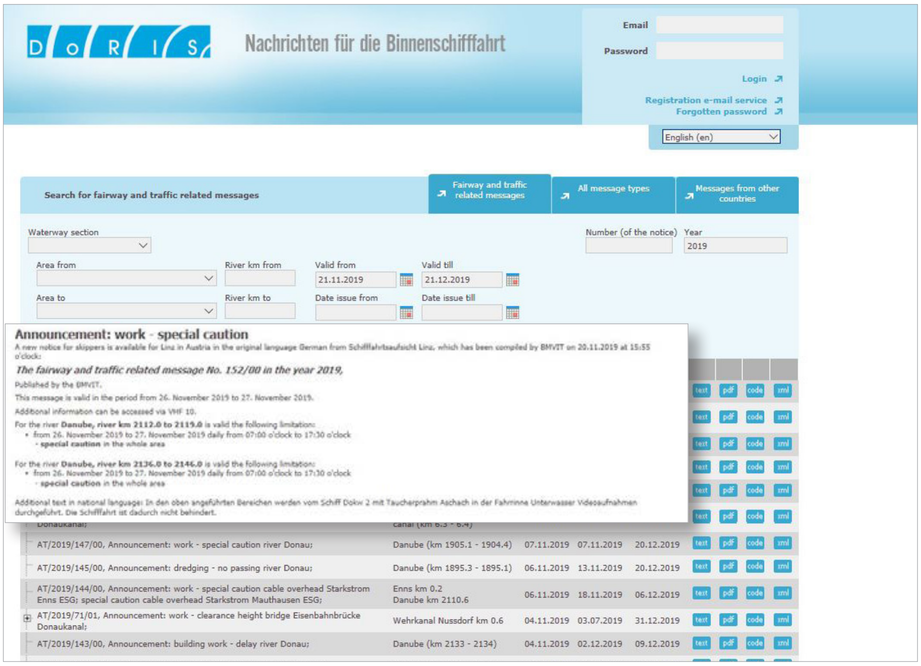
More information on Electronic Navigational Charts and Notices to Skippers can be found in the chapter 'River Information Services'.

The most common way to publish fairway-related information is either through Electronic Navigational Charts (Inland ENCs) or online via Notices to Skippers (NtS).



Source: viadonau

From basic data to the Electronic Navigational Chart; section of the Freudenau power plant in Vienna along the Austrian section of the Danube



Source: viadonau

Accessing a Notice for Skippers on the Austrian DoRIS portal

Static data such as bridge parameters, the dimensions and position of the fairway or results of bathymetric surveying activities are included in **Electronic Navigational Charts** which are updated on a regular basis.

Dynamic data such as water levels at gauges, prognoses of gauge heights or information on navigation restrictions and suspensions are provided via **Notices to Skippers** or can be directly accessed on the Internet.

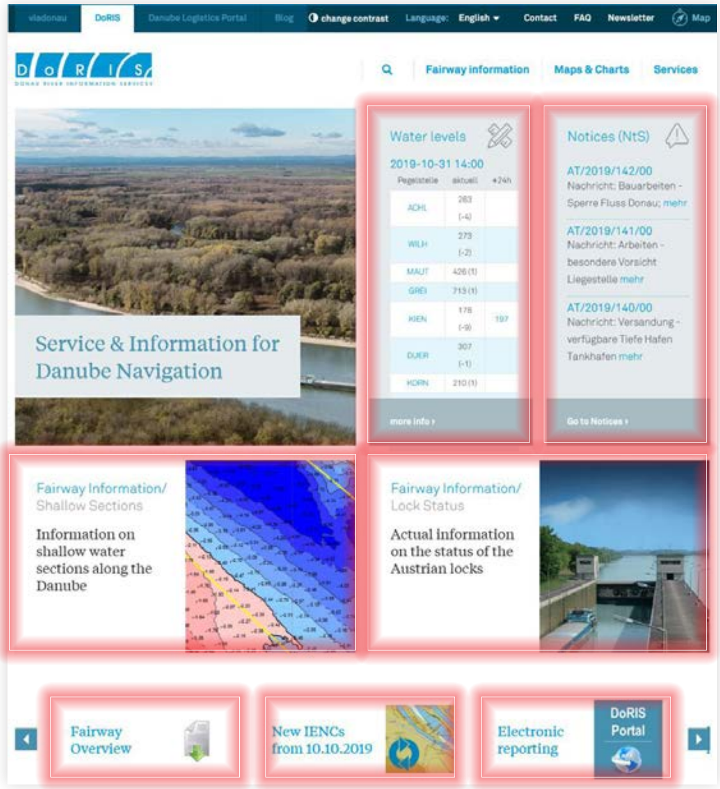
Digital fairway information in Austria

Donau River Information Services (DoRIS) provide extensive fairway informati-on services in Austria, in particular:

- Water levels: Information about the current water levels and level forecasts at ten gauge stations
- Shallow sections: Current fairway depths at important shallow sections of the two free-flowing sections of the Danube in Austria; a depth layer plan is available for each published shallow section, which also visualises the useable deep channel; shallow sections that are currently being dredged are marked accordingly.
- Vertical bridge clearance: The currently available clearance relative to the momentary water level is published for the seven bridges on the Austrian Danube that have the lowest vertical clearance heights.

- Notices to Skippers: Contain information concerning the waterway and traffic as well ice reports.
- Current operational status of the lock chambers in the nine locks along the Austrian Danube.
- Blocked stretches in cases of flooding or ice.
- The 'Overview on the actual fairway information' presents the current water levels, shallow sections, lock status and Notices to Skippers, summarised in one single PDF file.
- Electronic navigational charts are available online for the entire Austrian Danube section and can also be downloaded as PDF files and printed out.

The public RIS information is free of charge and can be accessed on the DoRIS website or using the smartphone app 'DoRIS Mobile' (for iOS and Android).

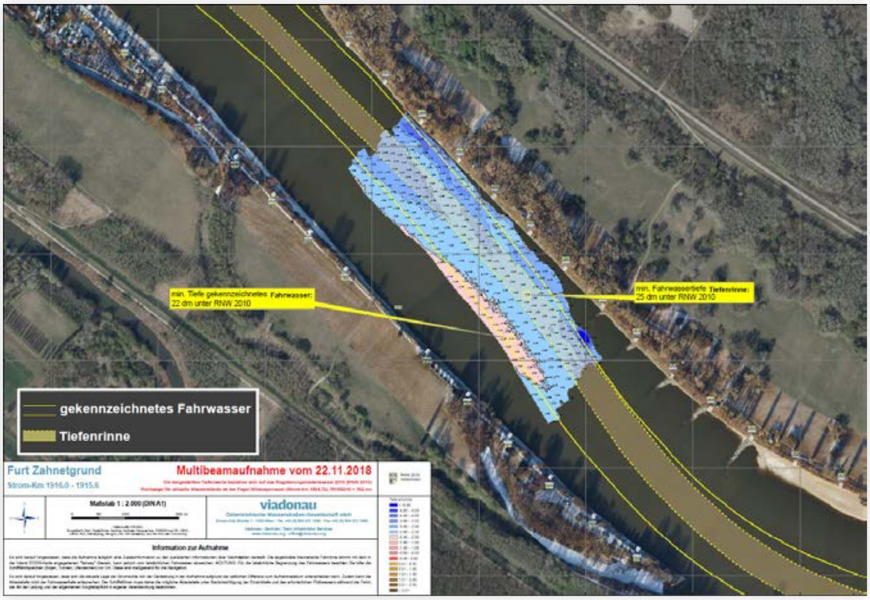


Source: viadonau

Online services on the DoRIS website

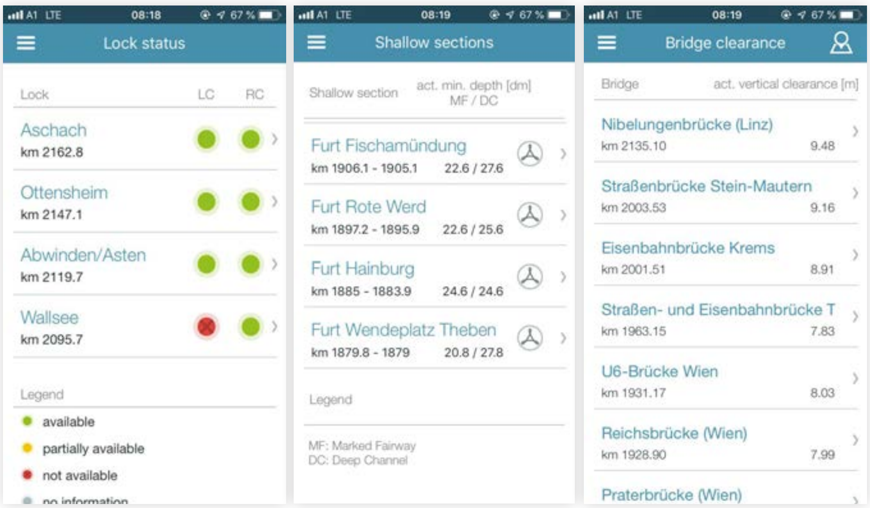
Current fairway information for the Austrian section of the Danube is available at the DoRIS website: www.doris.bmvit.gv.at/en,

as well as on the free smartphone app DoRIS Mobile:



Source: viadonau

Deep layer plan for a shallow section east of Vienna, with visualisation of the course of the marked fairway and the deep channel



Source: viadonau

Example of information from the DoRIS Mobile app

Improvement and extension of waterways

Apart from the maintenance of the fairway channel of inland waterways for the purpose of meeting the recommended fairway parameters, infrastructure work on waterways may also include the improvement or extension of the existing inland waterway network. The **improvement** of a waterway pertains to the upgrade of its UNECE waterway class or to the removal of so-called 'infrastructural bottlenecks'. The **extension** of the network can be the construction of new waterways which in some cases, according to the AGN, may be described as 'missing links'.

The maintenance, improvement and extension of inland waterways should always be accomplished by taking the following two main aspects of inland waterway infrastructure development into account:

- **Economics of inland navigation**, i.e. the connection between the existing waterway infrastructure and the efficiency of transport

- **Ecological effects of infrastructure works**, i.e. balancing environmental needs and the objectives of inland navigation (integrated planning)

Legal and political framework

The legal/political framework for the improvement and the extension of the inland waterway infrastructure network is set at the following different levels by the corresponding institutions as well as by strategic projects and documents:

- **Pan-European**: United Nations Economic Commission for Europe (UNECE) → international resolutions and agreements (AGN; Resolution No. 49 on the most important bottlenecks and missing links in the European inland water way network)

- **European**: European Union (mainly Directorates-General for Mobility and Transport, Regional and Urban Policy and Environment) → Danube waterway as part of Corridor 10 in the framework of the trans-European transport network; Priority Area 1a (To improve mobility and multimodality: Inland waterways) of the EU Strategy for the Danube region; Water Framework Directive, Natura 2000 network etc.

- **Regional (Danube region)**: Danube Commission, International Commission for the Protection of the Danube River, International Sava River Basin Commission → Belgrade Convention, Recommendations on the minimum requirements of fairway parameters as well as the improvement of the Danube by hydro-engineering and other measures, Plan for the principal works called for in the interests of navigation; Danube River Basin Management Plan, Joint Statement (cf. on the next page under 'Environmentally sustainable Danube navigation'); Framework Agreement on the Sava River Basin and accompanying strategy for its implementation

- **National**: national transport strategies and development plans of the ten Danube riparian states, as the maintenance and improvement of the infrastructure of inland waterways is a national competence of the countries concerned

@ Inland navigation at UNECE: www.unece.org/trans/main/sc3/sc3.html

@ Trans-European transport network: ec.europa.eu/transport/infrastructure

@ Priority area inland waterways in the Danube region strategy: www.danube-navigation.eu

@ Danube Commission: www.danubecommission.org

@ International Commission for the Protection of the Danube River: www.icpdr.org

@ International Sava River Basin Commission: www.savacommission.org

Source: viadonau based on the UNECE Blue Book

Infrastructural bottlenecks in the waterway network of the Danube region according to UNECE Resolution No 49

Environmentally sustainable Danube navigation

For more information on this topic, visit the website of the Commission for the Protection of the Danube River: www.icpdr.org/main/issues/navigation

Large river systems such as the Danube are highly complex, multi-dimensional, dynamic ecosystems and thus require comprehensive observation and management within their catchment area.

This kind of holistic approach is also required by the **Water Framework Directive** (WFD) of the European Union (European Commission, 2000). For international river basin district entities such as the Danube the WFD requires the coordination of international river basin management plans which also involve non-EU member states wherever possible. In the Danube river basin district, the **International Commission for the Protection of the Danube River** (ICPDR) is the platform for the coordination of the implementation of the WFD on the basin-wide scale between the Danube countries.

In 2008, the ICPDR, the Danube Commission and the International Sava River Basin Commission (ISRBC) endorsed a **Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin** (International Commission for the Protection of the Danube River, 2008). The statement provides guiding principles and criteria for the planning and implementation of waterway projects that establish consistency between the sometimes conflicting interests of navigation and the environment. It opts for an **interdisciplinary planning approach** and the establishment of a 'common language' across all disciplines involved in the process.

In order to facilitate and ensure the application of the Joint Statement, a **Manual on Good Practices in Sustainable Waterway Planning** has been developed by the ICPDR and relevant stakeholders in the Danube region within the framework of the EU project PLATINA in 2010 (Platform for the Implementation of NAIADES, 2010). It focuses on projects for a sustainable improvement and expansion of waterways. The basic philosophy is to integrate environmental objectives into the project design, thus preventing legal environmental barriers and significantly reducing the amount of potential compensation measures.

Source: viadonau/Zinner

Win-win for ecology and commerce: renatured banks and innovative form of groyne for regulation of low water levels on the free-flowing section of the Danube east of Vienna

The manual proposes the following **key characteristics for integrative planning**:

- Identification of integrated project objectives incorporating inland navigation aims, environmental needs and the objectives of other uses of the river reach such as nature protection, flood management and fishing
- Inclusion of important stakeholders in the early phase of a project
- Implementation of an integrated planning process to translate inland navigation and environmental objectives into concrete project measures thereby creating win-win results
- Performance of comprehensive environmental monitoring prior, during and after project works, thereby enabling an adaptive implementation of the project when necessary

While the focus of the 2010 **Manual on Good Practices in Sustainable Waterway Planning** is placed on future hydraulic engineering projects to optimise the infrastructure of inland waterways, the supplementary **Good Practice Manual on Inland Waterway Maintenance** addresses the eco-friendly and sustainable implementation of ongoing maintenance works on inland waterways by the waterway administration authorities.

The manual was published in 2016 as part of the EU's PLATINA II project and concentrates on the proactive maintenance of fairway channels in free-flowing sections of natural waterways in Europe. Among others, the maintenance measures include dredging at problematic areas, the relocation or (temporary) narrowing of the fairway course or the optimisation of current river structures in regard to their regulating or ecological effects.

@ Electronic versions of the good practice manuals: www.naiades.info/downloads

Catalogue of Measures for the Danube east of Vienna

via donau – Österreichische Wasserstraßen-Gesellschaft mbH, a subsidiary of the Austrian Federal Ministry for Transport, Innovation and Technology, adopts an integrative approach to stabilise the water level on the free-flowing section of the Danube east of Vienna, to preserve the unique habitat in the Danube-Auen National Park and to structure the waterway infrastructure in line with the requirements of safe and efficient Danube navigation. The corresponding Catalogue of Measures is the outcome of an interdisciplinary planning process.

Based on the insight acquired in the pilot project phase of the Integrated River Engineering Project, conservation activities will be combined with optimisation measures within hydraulic engineering:

- Integrative bedload management: In order to maintain safe and cost-effective navigable fairway conditions, gravel is excavated every year at the critical shallow sections. Gravel is also obtained from bedload traps specially set up for the purpose. This material is taken as far upstream as possible and dumped there in areas where the riverbed is deep. This counteracts the current-related removal of gravel (degradation) and thus secures the height of the riverbed. This bedload redistribution is enhanced by the external addition of gravel. Deep areas, in which the river has already largely washed out the gravel, are secured.
- Riverbank restoration: Natural riverbank structures are forming due to the local dismantling of the stone armour on the banks of the Danube. New habitats are being created for birds that breed on gravel banks and for typical riverine plant species. The river is reclaiming more space, which reduces the stress on the riverbed and lowers the water level in case of flooding.
- Sidearm reconnection: Branches bring life to the wetland forest and have become a rare type of habitat. They shape the landscape through erosion and sedimentation. Connections between the largest branch systems in the Danube-Auen National Park and the Danube will therefore be strengthened once again. The aim is to achieve the highest level of continuous flow so that the branch is active virtually all year round. This relieves pressure from the riverbed in the main channel and counteracts riverbed erosion. The resulting improved retention effect on the Danube wetlands also complements to constructive flood protection.
- Optimisation of the regulating structures: In order to ensure navigability also during low water periods and to reduce the operating costs of waterway infrastructure, low water regulation structures (groynes, training walls) are improved in critical ford areas (shallow sections). In areas of erosion, regulating measures can be moderately reduced by widening the channel to relieve pressure on the riverbed, thereby stabilising the water level.

Source: viadonau/Robert Tögel

Reconnected inlet opening for the Johler branch near Hainburg

Stakeholder participation: The involvement of the most diverse stakeholders and civil society is an important prerequisite for the development and implementation of socially and environmentally compatible solutions. Therefore, the implementation of the Catalogue of Measures is accompanied and supported by a participation model. At the centre of the model is an advisory board made up of representatives from industry, environmental NGOs, the ICPDR (International Commission for the Protection of the Danube River), the Donau-Auen National Park and viadonau. Further players who are affected or interested are involved in the course of ongoing information and discussion offerings.

A learning system: The Catalogue of Measures affords the flexibility required for new findings and current developments to be incorporated into the implementation. Ongoing preservation measures can be continually improved. The optimisation projects that are being implemented gradually according to their priority also enable constant further development from project to project. Continuous status evaluations and monitoring, or scientific support respectively are necessary for planning and success control ('learning from the river').

Project website:
www.lebendige-wasserstrasse.at

Source: viadonau

Loading of gravel; Reconstruction of a groyne

Waterway management in Austria

Home to 350.50 kilometres of river, Austria accounts for 10% of the total Rhine-Main-Danube waterway. Besides the Danube itself, the Vienna Danube Canal (17.1 km) and short sections of the Danube tributaries Traun (1.8 km), Enns (2.7 km) and March (6.0 km) are classified as waterways.

via donau – Österreichische Wasserstraßen-Gesellschaft mbH is responsible for maintaining the Austrian section of the Danube waterway and its navigable tributaries and canals. The company was founded in 2005 by the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) and is tasked with the conservation and development of the Danube waterway. The legal basis for all activities and services supplied by the company is provided by the **Waterways Act** (Federal Law Gazette I 177/2004). They include the establishment and provision of fairway parameters (waterway maintenance in accordance with the international provisions in force), the implementation of ecological hydraulic engineering and renaturation projects, the maintenance and restoration of river banks as well as the continuous provision of hydrographical and hydrological data. Regarding traffic management, viadonau operates an information and management system for navigation named DoRIS (Donau River Information Services) and is responsible for the management of the nine Austrian Danube locks. The headquarter of viadonau is located in Vienna; in order to carry out its tasks, the company also owns four branch offices along the Danube and March rivers.

via donau – Österreichische Wasserstraßen-Gesellschaft mbH

Adress: A-1220 Vienna, Donau-City-Strasse 1
Tel: +43 50 4321 1000 | Fax: +43 50 4321 1050

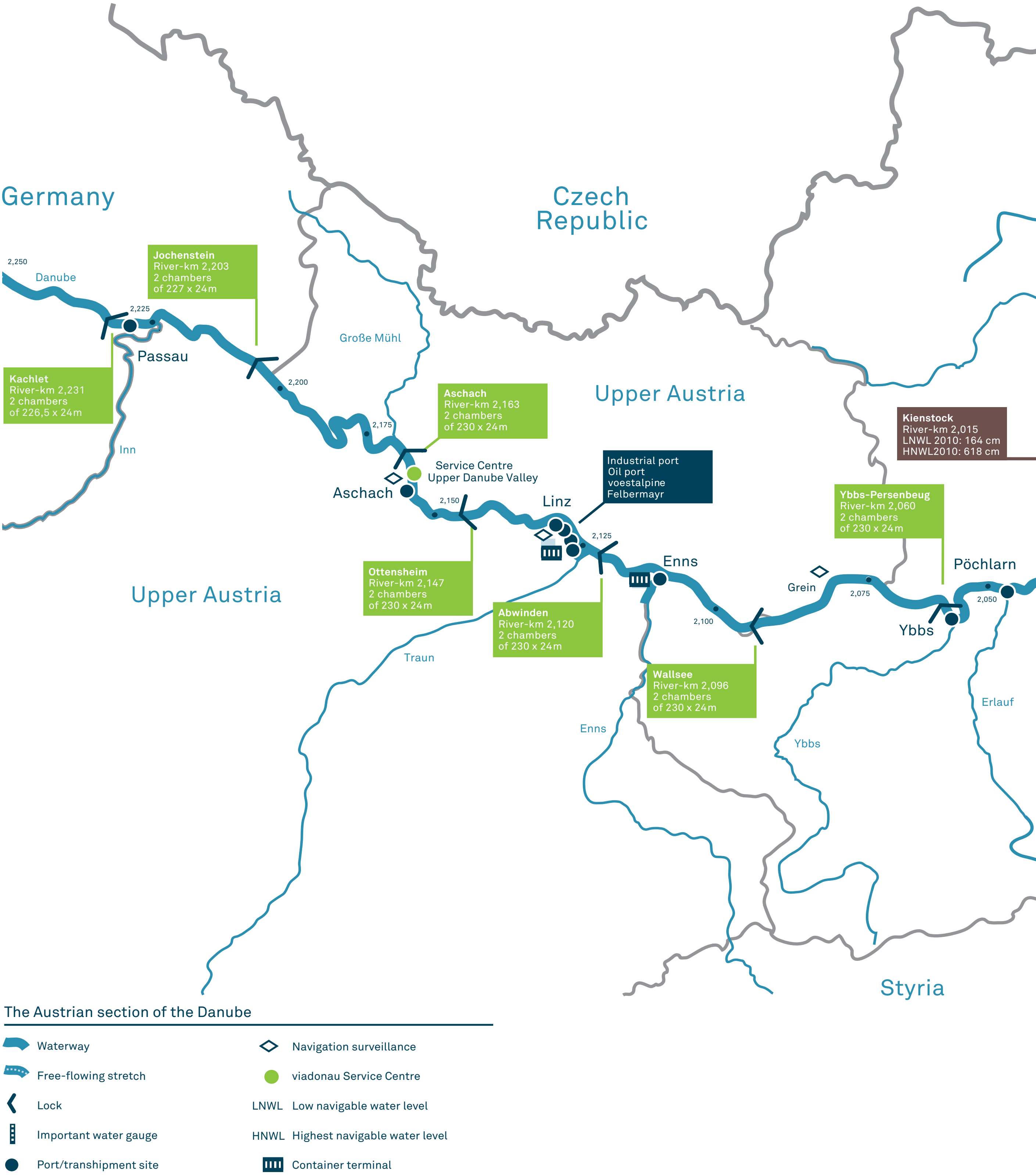
@ viadonau website:
www.viadonau.org

The strategic planning, control and monitoring of the administration of federal waterways rests with the **Federal Ministry for Transport, Innovation and Technology** (BMVIT). As a subordinate entity of the Supreme Navigation Authority (OSB) in the Ministry, navigation surveillance is carried out by nautically trained administration police who are responsible for ensuring the consistent administration of navigation on the Austrian section of the international Danube waterway within the framework of the 'Belgrade Convention'. Among the tasks of the navigation surveillance, which has six field offices along the Danube in Austria, are navigation control, the supervision of adherence to all administrative regulations pertaining to navigation, the issuing of directives to the users of the waterway and assistance for damaged vessels.

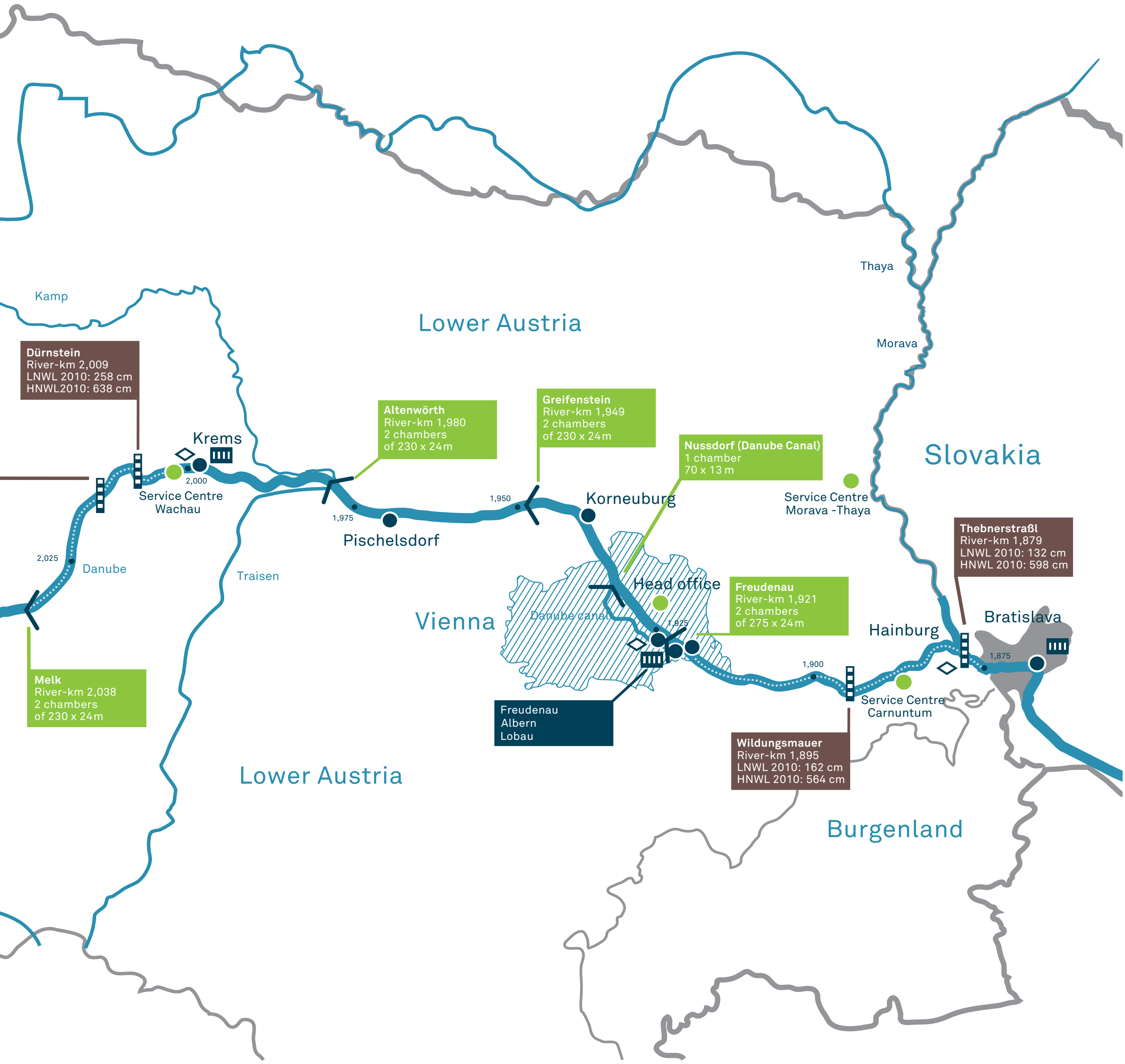
Supreme Navigation Authority
within the Federal Ministry for Transport, Innovation and Technology.

Adress: A-1030 Vienna, Radetzkystrasse 2
Tel: +43 1 71162 655903 | Fax: +43 1 71162 655999

BMVIT website:
www.bmvit.gv.at



The Austrian section of the Danube including offices and branch offices of viadonau and navigation surveillance



Source: viadonau

The Danube economic region

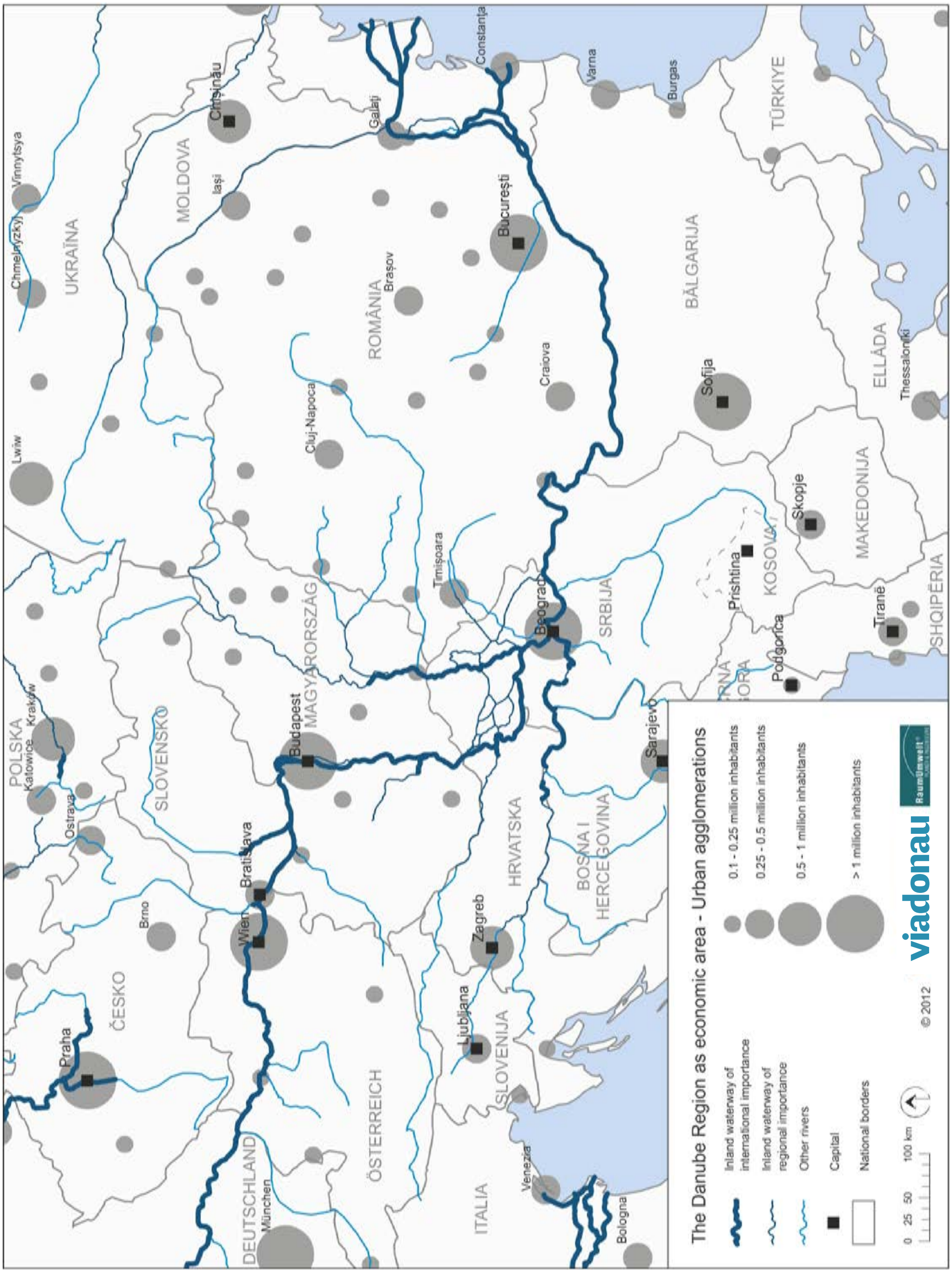
The Danube as an axis of economic development

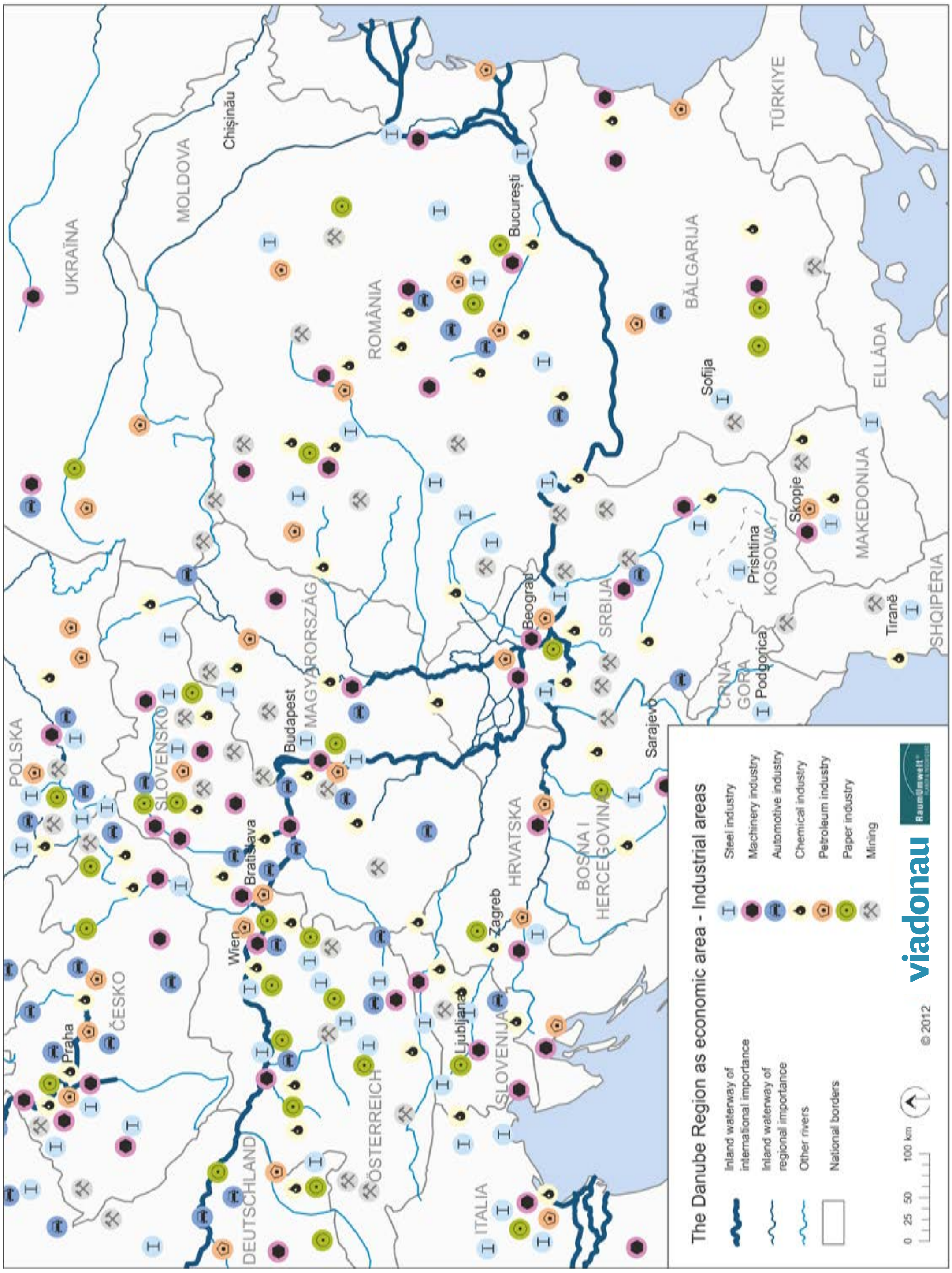
In its function as a transport axis the Danube connects key procurement, production and sales markets that have significant European importance. The **gradual integration of the Danube riparian states into the European Union** has led to the establishment of dynamic economic regions and trading links along the waterway. Slovakia's and Hungary's accession to the EU in the year 2004 followed by Bulgaria and Romania in 2007, as well as Croatia's accession in 2013, marked the start of a new phase of economic development in the Danube region. Serbia was given accession candidate status in 2012. Accession negotiations with the European Union started in 2014.

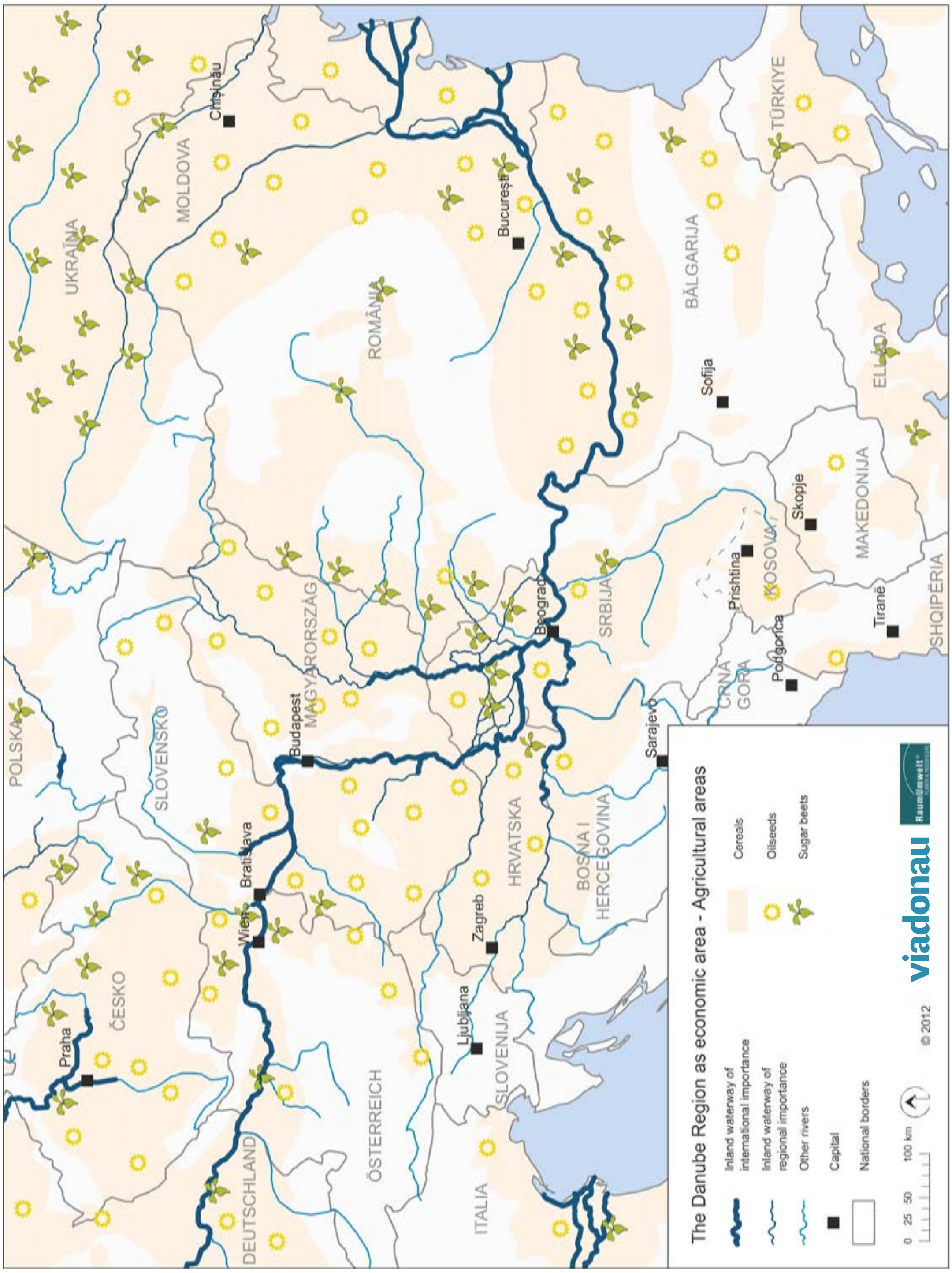
With approximately **90 million inhabitants**, the Danube region is of great economic interest. The focus of this economic development lies in the capital cities of the Danube countries. Other urban areas are also playing an ever increasing role, in particular as consumer and sales markets. The Danube waterway as a transport mode can make a major contribution here with the provision of these centres with raw materials, semi-finished and finished products as well as the disposal of used materials and waste.

The Danube is of particular importance as a transport mode for the **industrial sites** that are located along the Danube corridor. Bulk freight capacity, the proximity to raw material markets, large free transport capacities and low transport costs all add up to make inland navigation the logical partner for resource-intensive industries. Many production facilities for the steel, paper, petroleum and chemical industries along with the mechanical engineering and automotive industry are to be found within the catchment area of the Danube. Project cargo and high-quality general cargo are now being transported on the Danube in ever increasing numbers in addition to traditional bulk cargo.

Due to its fertile soil, the Danube region is an important area for the cultivation of **agricultural raw materials**. These not only serve to ensure the sustainable provision of the conurbations in the vicinity of the Danube, but are also transported along the logistical axis of the Danube to be further processed. The ports and transhipment sites along the Danube play an important role here as locations for storage and processing and as goods collection points and distribution centres. A not inconsiderable part of these agricultural goods is exported overseas via the Rhine-Main-Danube axis and the respective seaports (North Sea and Black Sea).


The Danube Region as economic area - Urban agglomerations
Inland waterway of international importance
Inland waterway of regional importance
Other rivers
Capital
National borders
0.1 - 0.25 million inhabitants
0.25 - 0.5 million inhabitants
0.5 - 1 million inhabitants
> 1 million inhabitants
0 25 50 100 km
© 2012
viadonau
ČESKO
ÖSTERREICH
DEUTSCHLAND
ITALIA
SLOVENIJA
HRVATSKA
BOSNA I HERCEGOVINA
MAGYARORSZÁG
SLOVENSKO
POLSKA
UKRAÏNA
MOLDOVA
ROMÂNIA
BĂLGARIJA
SRBIJA
KOSOVA
MAKEDONIJA
SHQIPËRIA
ELLÁDA
TÜRKIYE
Praha
Brno
Wien
Bratislava
Budapest
Ostrava
Katowice
Kraków
Lwiw
Chmelnyzkyj
Vinnytsya
Chişinău
Iaşi
Galaţi
Constanţa
Varna
Burgas
Bucureşti
Braşov
Cluj-Napoca
Timişoara
Craiova
Sofija
Beograd
Skopje
Prishtina
Podgorica
Tiranë
Thessaloniki
Sarajevo
Zagreb
Ljubljana
Venezia
Bologna
München

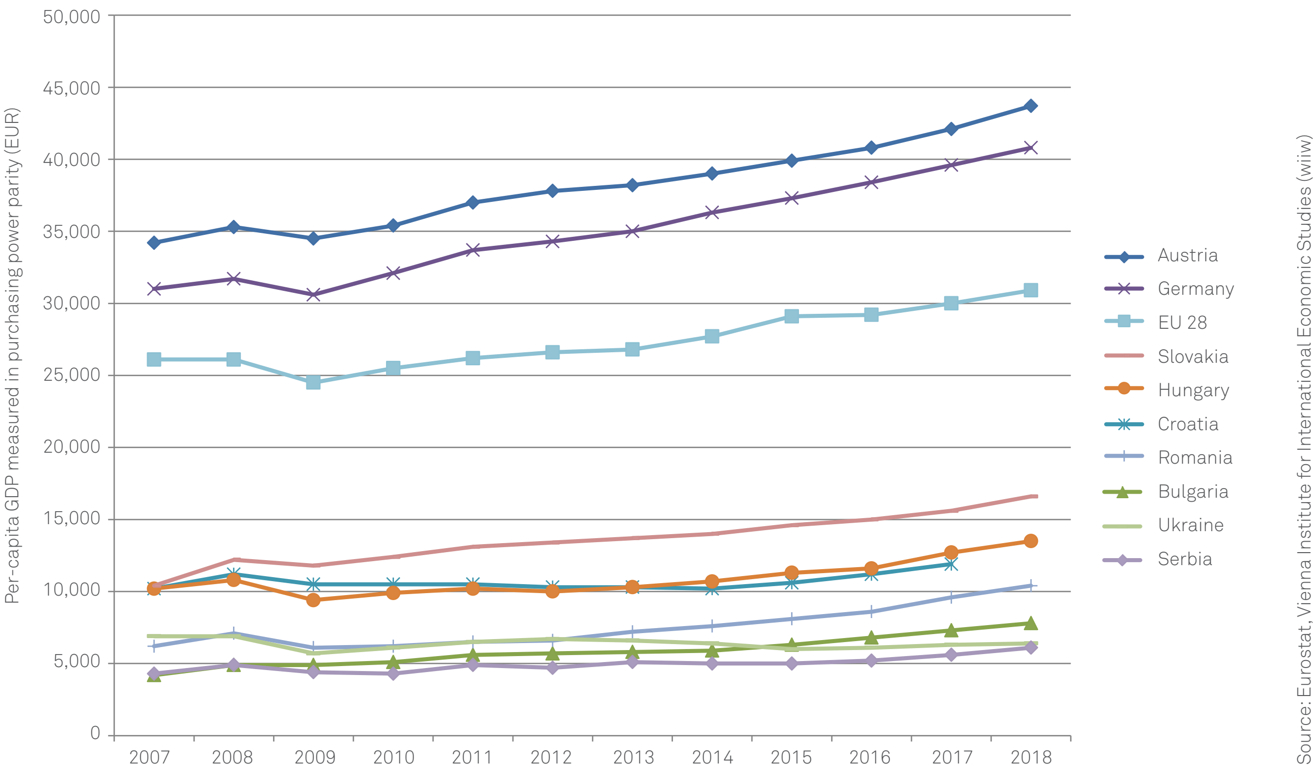

The Danube Region as economic area - Industrial areas
Inland waterway of international importance
Inland waterway of regional importance
Other rivers
National borders
Steel industry
Machinery industry
Automotive industry
Chemical industry
Petroleum industry
Paper industry
Mining
0 25 50 100 km
© 2012
viadonau
UKRAÏNA
MOLDOVA
Chişinău
ROMÂNIA
Bucureşti
BĂLGARIJA
Sofija
TÜRKIYE
ELLÁDA
MAKEDONIJA
Skopje
KOSOVA
Prishtina
SHQIPËRIA
Tiranë
CRNA GORA
Podgorica
SRBIJA
Beograd
BOSNA I HERCEGOVINA
Sarajevo
HRVATSKA
Zagreb
SLOVENIJA
Ljubljana
ITALIA
ÖSTERREICH
Wien
DEUTSCHLAND
ČESKO
Praha
POLSKA
SLOVENSKO
Bratislava
MAGYARORSZÁG
Budapest


The Danube Region as economic area - Agricultural areas
Inland waterway of international importance
Inland waterway of regional importance
Other rivers
Capital
National borders
Cereals
Oilseeds
Sugar beets
0 25 50 100 km
© 2012
viadonau
POLSKA
UKRAÏNA
MOLDOVA
ČESKO
SLOVENSKO
DEUTSCHLAND
ÖSTERREICH
MAGYARORSZÁG
ROMÂNIA
ITALIA
SLOVENIJA
HRVATSKA
BOSNA I HERCEGOVINA
SRBIJA
CRNA GORA
KOSOVA
MAKEDONIJA
SHQIPËRIA
BĂLGARIJA
ELLÁDA
TÜRKIYE
Praha
Wien
Bratislava
Budapest
Chişinău
Bucureşti
Ljubljana
Zagreb
Sarajevo
Beograd
Podgorica
Prishtina
Skopje
Tiranë
Sofija

Competitiveness and growth

Among the most striking characteristics of the Danube region are the substantial differences in national income and macroeconomic productivity. The **income and productivity levels** – measured in purchasing power parity of per-capita gross domestic product (GDP) – ranged from approximately 43,700 Euros in Austria to 6,100 Euros in Serbia in the year 2018. This was equivalent to a ratio of almost 7:1.

A clear picture emerges if you take a detailed look at the development of GDP in the individual Danube riparian states in recent years: All Danube riparian states have recorded steady growth since the economic crisis of 2009.



According to the national statistics agency of Croatia, no data for 2018 was available at the time of the publication of this manual;

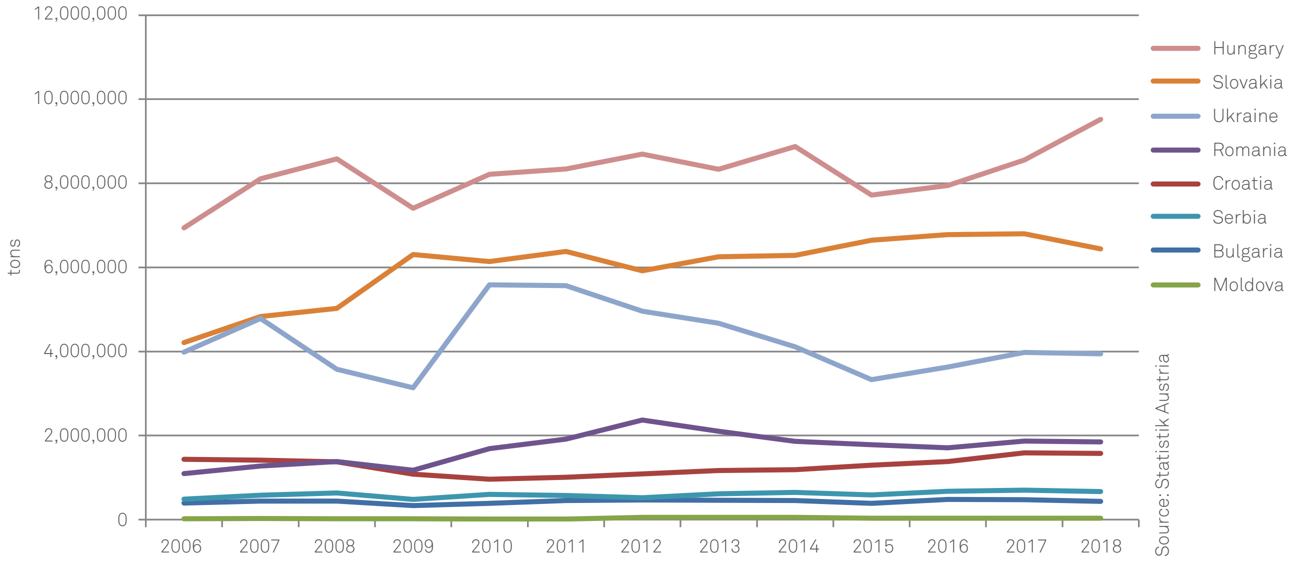
GDP development in the Danube region

Austria's foreign trade links in the Danube region

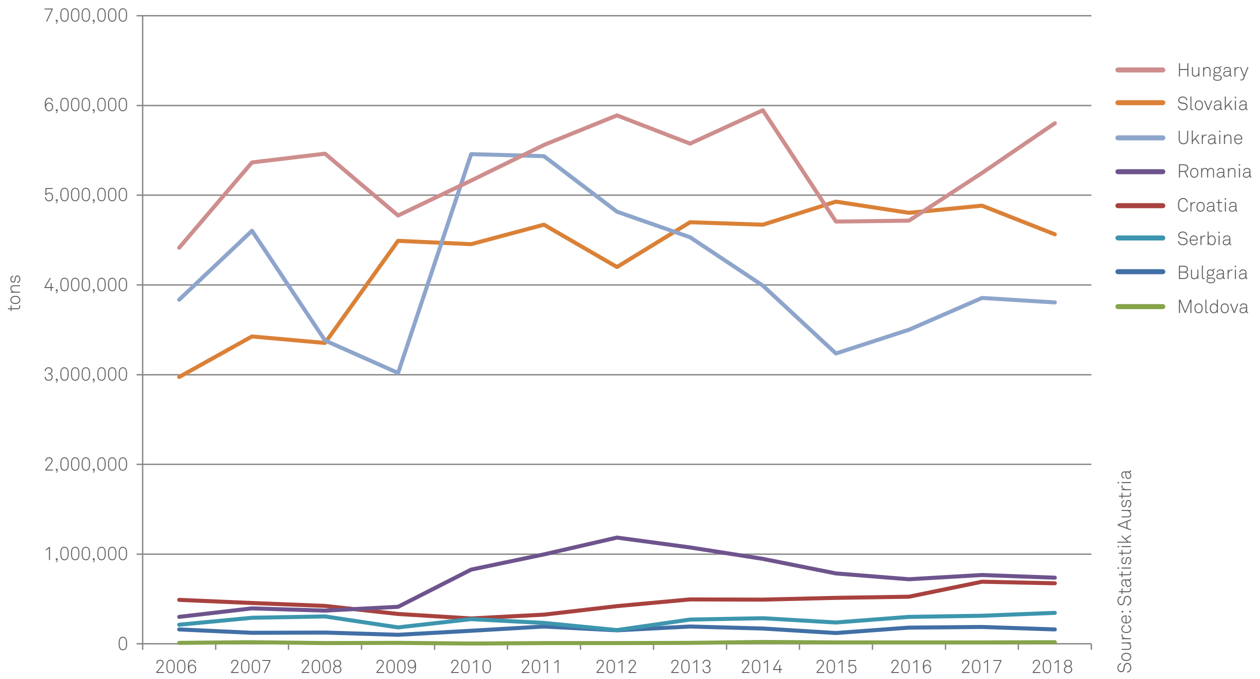
Increasing deregulation of the European single market and integration of the states of Central and South-Eastern Europe within the European Union have led to a fundamental restructuring of foreign trade flows in recent years. The Danube riparian states and Austria in particular have benefited from this development.

With an annual trade volume of about 47 million tons in 2018 (combined imports and exports), Germany is Austria's most important trade partner by far. Nonetheless, the data for Germany was consciously omitted from the following diagram in order to focus on Austria's trade relationships with the states of Central and Eastern Europe.

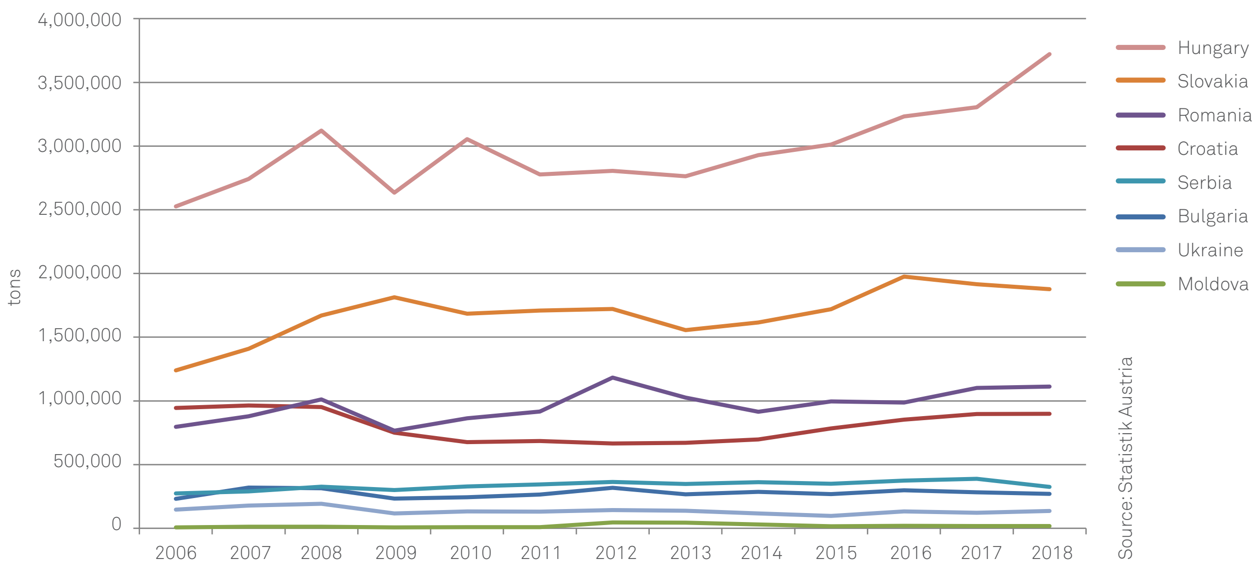
Austria's accumulated export trade volumes in the Danube region have risen by 5.9 million tons or 31.8% since 2006.



Austria's foreign trade links in the Danube region 2006–2018



Austrian imports from the Danube region 2006–2018



Austrian exports to the Danube region 2006–2018

Hungary is Austria's most important trade partner among Central and Eastern European countries.

Hungary, Slovakia and Ukraine top the list for **imports** to Austria. In total, 16.1 million tons of goods were imported to Austria from the Danube riparian states (not counting Germany) in 2018. This is equivalent to a growth rate of 29.9% since 2006.

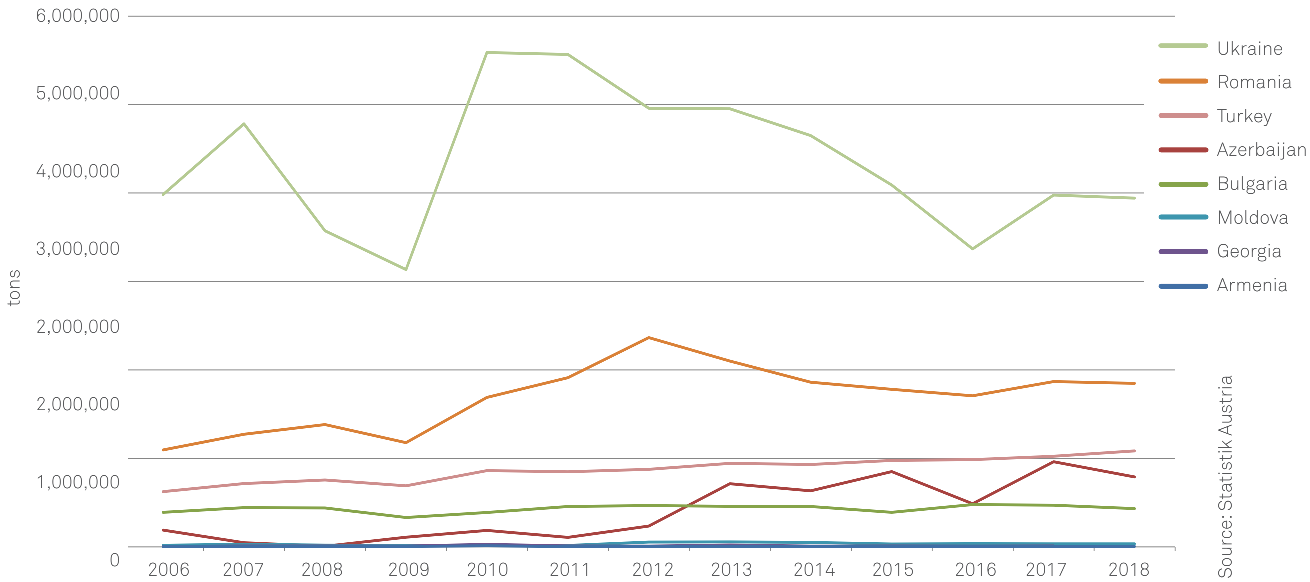
Hungary takes the top slot for **exports** to the Danube region by a considerable margin. It is followed in second and third place by Slovakia and Romania, respectively. In total, 8.4 million tons of goods were exported to the Danube riparian states (not counting Germany) from Austria in 2018. This is equivalent to a growth rate of 35.6% since 2006.

The Danube as a link to the Black Sea region

For the European Union, the Danube represents an important link to the Black Sea region. With more than 145 million inhabitants, this region is a future market with considerable development potential.

The Black Sea region comprises Armenia, Azerbaijan, Georgia, the Republic of Moldova, the Russian Province of Krasnodar (Sotchi), Turkey and Ukraine, as well as the two EU member states Romania and Bulgaria, whose national economies are becoming increasingly linked with the Black Sea riparian states via the seaports (e.g. Constanţa, Varna).

The EU Strategy for the Danube Region and transnational projects could open up further opportunities for increased cooperation with the Black Sea region.



Austria's foreign trade links in the Black Sea region 2006–2018

Austria's foreign trade links with the Black Sea region

Among the Black Sea riparian states, the Russian Federation is by far the most important trade partner for Austria. No clearly assignable data material is available for the region of Krasnodar bordering the Black Sea, so Russia was consciously omitted from the diagram in order to preserve the regional focus.

Despite fluctuating trade volumes, Ukraine is still one of Austria's most important trade partners in the Black Sea region, accounting for 3.9 million tons in 2018. Romania comes second with approximately 1.8 million tons, and trade volumes with Turkey, as the third most important partner, have risen steadily since 2006 (2018: 1.1 million tons).

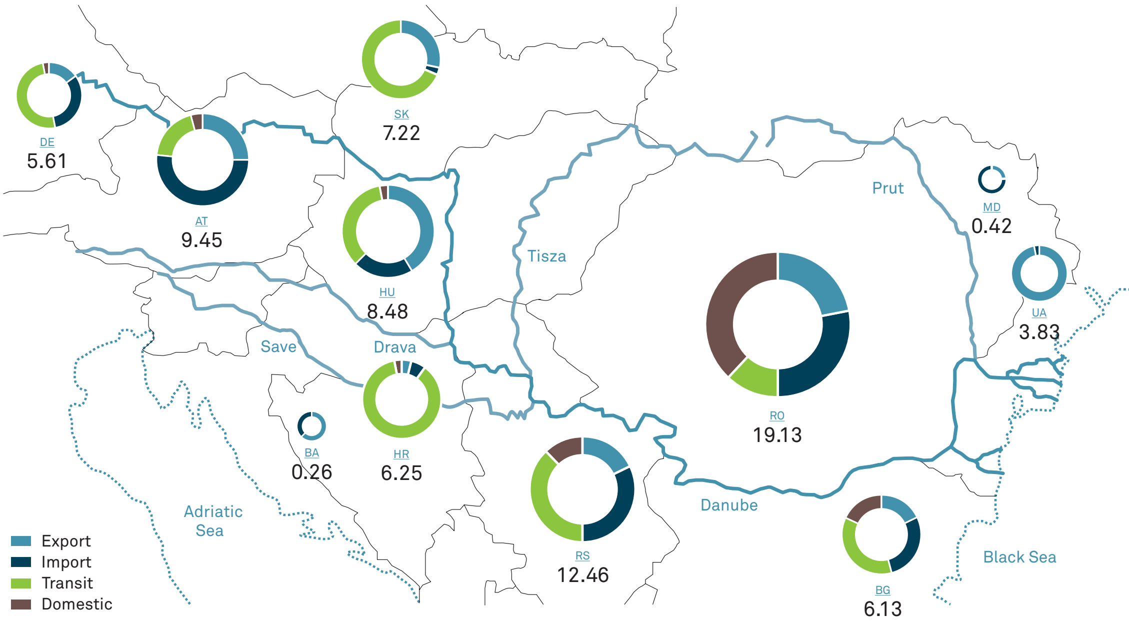
Processed goods (especially for Romania and Turkey), as well as chemical products and raw materials (for Romania) are Austria's principal **export** categories. Raw materials (mainly ores and steel from Ukraine), fuels (from Azerbaijan) and foods (from Romania) are the main categories on the **import** side.

Transport volume

The latest figures available for the overall volume of goods transported on inland waterways within the Danube region date from the year 2017 (viadonau, 2019). This data provides a good overview of the volumes transported, major transport relations and the importance of Danube navigation in the riparian states.

In total, **39.3 million tons of goods** were transported on the Danube waterway and its tributaries in the year 2017. These and all the following figures include both transport by inland vessels and river-sea transport on the maritime Danube (Sulina and Kilia arm) up to the Romanian port of Brăila (river-km 170) as well as goods transported on the Romanian Danube-Black Sea Canal.

By far the largest transport volume for 2017 was recorded by Romania with 19.1 million tons, followed by Serbia with 12.5 million tons and Austria with 9.5 million tons. Romania was the **biggest** Danube **exporter** in 2017. In total, Romania shipped 4.2 million tons of goods in this year. Of all the Danube riparian states, Romania also had **the biggest volume of imports** in the year 2017 – standing at 5.4 million tons. As far as **transit traffic** on the Danube was concerned, the largest transport volume of 5.7 million tons was registered in Croatia. Romania was again by far the most important country for **domestic transport**, with 7.3 million tons.



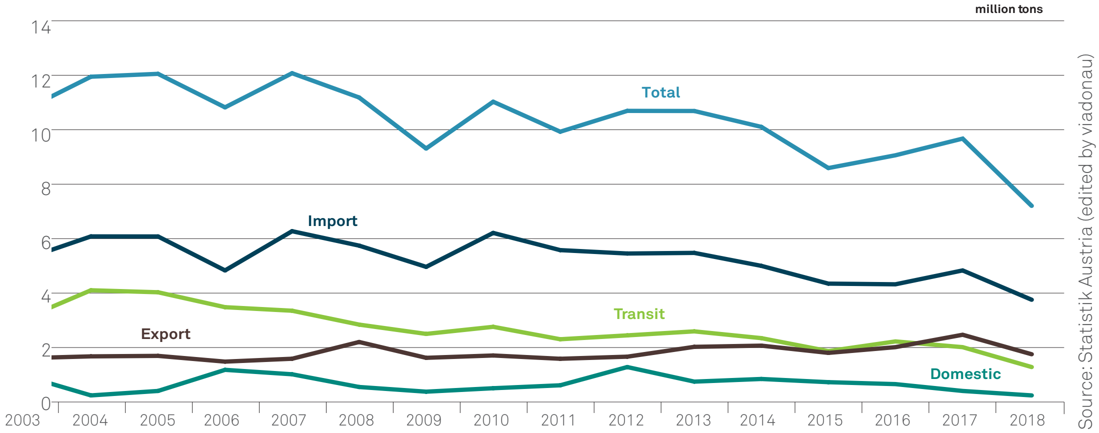
Million Tons	DE	AT	SK	HU	HR	BA	RS	RO	BG	MD	UA
Export	0.84	2.40	2.09	3.50	0.19	0.17	2.30	4.21	1.11	0.10	3.67
Import	1.81	4.82	0.10	1.81	0.33	0.09	3.96	5.40	1.73	0.32	0.15
Transit	2.78	1.84	5.01	2.92	5.67	0.00	4.76	2.20	2.20	0.00	0.00
Domestic	0.18	0.39	0.02	0.25	0.06	0.00	1.44	7.32	1.09	0.00	0.01
Total	5.61	9.45	7.22	8.48	6.25	0.26	12.46	19.13	6.13	0.42	3.83

Source: Eurostat, national transport statistics, viadonau (edited by viadonau)

Transport volume on the Danube and its navigable tributaries in 2017

Transport volumes in Austria

The following diagram visualises developments in goods transport on the Austrian section of the Danube in a long-term review. Besides the economic situation, low water periods especially have significantly affected traffic volumes on the Danube. These circumstances highlight the need for proactive transport policies to rectify the nautical issues along the Danube as quickly as possible and to introduce customer-oriented and proactive water management along the entire Danube based on the Austrian model. This is the only way to ensure an effective shift of transports towards Danube navigation.



Transport volume on the Austrian Danube 2003–2018

Dry bulk transports (coal, ore and corn) and **liquid bulk transports** (mainly petroleum) account for the largest share of goods transports. Industrial sectors in Austria that require high volumes of raw materials benefit in particular from this low-cost transport mode and its bulk freight capacity. For instance, most of the raw materials supplied to the voestalpine steel plant in Linz are carried by inland vessels.

The western section to the North Sea ports of Amsterdam, Rotterdam and Antwerp is predominantly used to transport **semi-finished and finished products**. Transits play an important role in the transport of **agricultural products** from Hungary, Bulgaria and Romania to Western Europe.

On the Austrian side, however, there are increasing volumes of **higher-quality general cargo** transports by inland vessel. Besides RoRo transports (e.g. new vehicles, as well as agricultural and construction machinery), the Danube is principally used to carry project cargo (heavy and oversized cargo such as transformers, turbines and generators).

Market characteristics

Liberalisation and deregulation of the transport markets have made great headway within the European Union. In the Danube region, however, the political and legal framework conditions remain relatively heterogeneous due to the recent, or rather not yet concluded, accession of individual Danube riparian states to the European Union. In this respect, **greater harmonisation** is expected over the coming years and this will favour the entry of additional buyers and sellers in the market and in turn promote the opening up of new transport potential.

To date, the largest portion of goods transported on the Danube waterway originate from a few **major cargo owners** who deal with only a relatively small number of service providers. The **large shipping companies** are, for the most part, derived from former state-owned enterprises mainly and provide cargo space for the transport of traditional bulk goods based on long-term open policies. Smaller shipping companies and **independent ship owners** (private vessel owner-operators) often have to be more flexible in finding cargoes and for the most part serve economic niches and short-term requirements for transport services.

Transport operations are carried out on the basis of a **freight contract** (or contract of carriage) which is concluded between the consignor and the freight carrier either directly or indirectly. In the case of direct conclusion, the contract is concluded directly between the cargo owner and the shipping company. In contrast, there is at least one other party involved who acts as an intermediary if a contract is concluded indirectly (e.g. a forwarder or freighting company). The freight contract is concluded consensually between the parties. There is no special form required (freedom from any formal requirements).

A consignment note that serves as documentation for the transport operation is drawn up for each individual freight order. A bill of lading often regulates the legal relationship between the freight carrier and the consignee in inland navigation. The bill of lading provides the consignee with evidence of the right to receive the consignment and obliges the freight carrier to hand over the goods only on submission of the bill of lading. This transport document is customary in inland navigation and constitutes a document of title, the submission of which leads to a transfer of ownership of the goods. In other words, the bill of lading functions as a certificate of receipt for the goods, as a carriage promise for the transport of the goods and a promise to hand over the goods to the legitimate owner of the bill.

The parties involved in the inland waterway transport market will be dealt with in detail in the following. The contract forms used for Danube navigation and the transport modes on which they are based are also described in this section.

Supply side of Danube navigation

Logistics providers on the Danube navigation market include primarily transport companies, companies acting as intermediaries (freighting companies, forwarders), as well as port and terminal operators.

Transport companies

Shipping companies are commercial ship transport companies that professionally organise and implement the transport of goods. They use their own vessels or those from other companies for this purpose. Several ships are operated in all cases. Shipping companies are distinguished by the fact that they prepare and direct transport from land (in contrast to independent ship owners who usually do not have such a 'land-based organisation').

In addition to such shipping companies, the independent ship owners (**private vessel owner-operators**) mentioned above are also active on the market. Most of these operate a single motor cargo vessel, some own up to three vessels. As a rule, independent ship owners also act as captains of their own ships and do not normally run any land-based commercial offices. In many cases they are organised into co-operatives.

Source: viadonau

Motor cargo vessel

Companies acting as intermediaries

Companies without their own fleet of vessels can also act as intermediaries for the provision of cargo space. In such cases, contracts of carriage are concluded directly.

In order to market their services, both shipping companies as well as independent ship owners often use ship brokers. The ship broker is the contract partner of the enterprise placing the order for transport and functions as a broker for rented cargo space. As a rule, the relationship between the owner of the vessel and the **ship broker** is regulated by means of a subcharter. In other words, the broker acts as both freight carrier and consignor.

Forwarders specialised in inland waterway transport or forwarders' specialised business units also play an important role in Danube navigation. Here, too, the freight contract is concluded indirectly: The forwarding company, in its function as a service provider, concludes a forwarding contract with the shipper. The forwarding contract differs from the freight contract in that it obliges to provide the transport of the goods. The shipping company or the independent ship owner is obliged to transport the cargo. A freight contract, which is concluded with a shipping company or an independent ship owner in the name of the forwarder, but at the cost of its customer, regulates the relationship between these two parties.

(Shipping) agencies mostly represent several shipping companies and carry out all the tasks of a commercial agent on another company's behalf but for their own account. These tasks include freight acquisition, preparation of documents, invoicing, collection of charges or complaints processing. Freight contracts are in turn concluded indirectly between agents and consignors.

Port and terminal operators

Further information on ports and terminals can be found in the chapter 'System elements of Danube navigation: Ports and terminals'

Ports and terminals can be operated privately or as public facilities. However, provision of the logistic services at one port or transhipment site often comprises of co-operation between private and public parties.

The transhipment and storage of goods are among the basic functions of ports and terminals. As a rule, ports also offer a whole series of logistical value added services for customers such as packing, stuffing and stripping of containers, sanitation and quality checks for customers and border checks at the outer borders of the Schengen Area (Croatia, Romania and Bulgaria are not yet members of the Schengen Area; Serbia, Moldova and Ukraine are not EU Members).

Transport companies operating on the Danube

The Blue Pages

'The Blue Pages' have been an indispensable source of information for cargo owners in the Danube region since 2009. The comprehensive directory of shipping companies and ship brokers operating on the Danube can be accessed in English at www.danube-logistics.info/the-blue-pages. Companies are invited to create a free business profile to field enquiries for transport services.

Danube Ports

'Danube Ports' provides information and data on more than 60 ports and terminals along the entire Danube. The online platform can be accessed at www.danube-logistics.info/danube-ports. Besides general information, the detailed port profiles include contact details of the port operator and administration, important data on the infra- and suprastructure, as well as on storage and transhipment facilities. The local terminal operators and their services are described as well.

Demand side of Danube navigation

The demand side of the inland waterway transport market firstly includes, for the most part, cargo owners, i.e. industrial companies that receive or convey goods. Secondly there are forwarders and logistics service providers operating in this field who carry out transport for third parties as well.

Traditional markets of Danube navigation

Due to the large volume of goods that can be transported on a vessel unit, inland navigation vessels are ideally suited to the transport of bulk cargo. If planned and carried out correctly, transport costs can be reduced in comparison to road and rail and this in turn compensates for longer transport times. The inland vessel is especially suitable for the transport of large quantities of cargo over long distances.

However, the system requires the availability of high-quality logistics services along the waterway (transhipment, storage, processing, collection and/or distribution). Many companies use Danube navigation as a fixed part of their logistics chain. Currently, the great bulk freight capacity of inland vessels is utilised predominantly by the metal industry, agriculture and forestry and the petroleum industry.

Inland navigation is a vital transport mode for the **steel industry**. Iron ore accounts for example for 25-30% of the total transport volume shipped on the Austrian stretch of the Danube. Due to their heavy weight, semi-finished and finished goods such as steel coils can also be transported economically using inland navigation.

The most important steel plant in Austria is voestalpine, which is headquartered in Linz. This company operates a private port on its own premises that has an annual waterside transhipment of 3-4 million tons. This is also Austria's most important port in that it has handled almost half of all waterside transhipment in Austria in recent years.

Source: viadonau

Transhipment of steel coils

Other major steel plants in the Danube region are located in Dunaújváros/Hungary (ISD Dunaferr Group), Smederevo/Serbia (HBIS Group) and Galaţi/Romania (Arcelor-Mittal).

The demand and, therefore, also the flow of goods from the **agriculture and forestry sector** can fluctuate greatly from one year to the next. Agriculture is dependent to a great extent on weather conditions (precipitation, temperature, days of sunshine per year). Crop failures in a region due to bad weather conditions can lead to a fluctuation in the volume of transported goods required to cover the needs of the affected region. Grain and oilseed are the main products transported on the Danube. Wood transports (for instance logs, pellets) vary greatly, depending on the regional raw material availability.

Agricultural and forestry products together account for around 20% of the total volume of goods transported annually on the Austrian stretch of the Danube. Many Austrian companies trading in agricultural products or involved in the processing of such goods (i.e. starch, foodstuffs and animal fodder, biogenic fuel) have settled directly on the waterway. Many companies have already established factory transhipment sites or have settled in a port where they operate their silos or processing facilities. This enables transport on inland vessels with no pre- or end-haulage, thereby enabling companies to benefit from particularly low transport costs.

Source: Voies navigables de France

Transhipment of agricultural goods

Petroleum products from the **mineral oil industry** account for a large share of total transport volumes on the Austrian stretch of the Danube and therefore constitute a key market. In the Danube region there are many refineries located either on or near the waterway.

Due to their great bulk freight capacity, low transport costs and high level of safety, inland vessels are absolutely ideal as a significant means of transport for petroleum products in addition to pipelines. The fuel tanks of around 20,000 cars can be filled up with the cargo of a single tanker. As a transport axis, the Danube waterway therefore makes an important contribution to the security of supply in the region.

Petroleum products and their derivatives are classed as hazardous goods and for this reason are transported in special vessel units equipped with the respective safety equipment. European regulations and national hazardous goods legislation have particular relevance for tanker shipping.

Other branch-specific potential for Danube navigation

In addition to traditional bulk cargo transport, there are numerous sectors involved in the transport of high-value goods, which, due to their specific requirements, represent a great challenge but at the same time a substantial potential for the development of logistics services along the waterway.

Due to their size and/or their weight, as well as the available infrastructure, inland vessels are ideally suited for special transport such as **heavy goods or oversized cargo** (high & heavy), e.g. construction machinery, generators, turbines or wind power plants. The greatest advantages here compared to conventional road transport are that no special authorisations or modifications are needed along the route, e.g. the dismantling of traffic lights and traffic signs or protective covers for plants. In addition, charges such as toll or axle load taxes are not levied on international waterways like the Danube. Another benefit is the fact that there is no inconvenience to the general public due to street closures, restrictions on overtaking or noise when such goods are transported by inland vessel.

Source: viadonau

High & heavy transport by inland vessels

The Rhine river

The Rhine is 1320 km long in total, of which 884 km are navigable. The navigable section starts at Basel in Switzerland and ends in Rotterdam in the Netherlands. The Rhine flows through four countries - Switzerland, Germany, France and the Netherlands.[1]

The Central Commission for Navigation on the Rhine (CCNR) is the competent authority for navigation on the Rhine. It was founded in 1815 at the Congress of Vienna and authorised in 1868 by the Mannheim Act to ensure the prosperity of navigation on the Rhine and throughout Europe as well as a high level of safety for shipping and its environment. The CCNR's work involves the five member states - Germany, Belgium, France, the Netherlands and Switzerland - and a number of observer states. The CCNR has the task of taking all initiatives to promote and guarantee navigation on the Rhine. Since its 200 years of existence, the CCNR has contributed to the development of inland navigation law, has been responsible for regulating navigation on the Rhine and for ensuring good navigation conditions on the Rhine. The CCNR also coordinates national regulations on social protection for boatmen and promotes environmentally friendly inland navigation.[2]

Some 330,000 tonnes of goods are transported on the Rhine every year. The Rhine is considered the most important inland waterway route and forms the backbone of European inland navigation. Two thirds of all goods transported by inland navigation are shipped via the Rhine. The main markets served by Rhine navigation are the transport of mineral products, building materials, solid fuels and machinery. But new markets are also booming, such as the transport of containers, weight-intensive goods, chemicals and passengers.[3]

The main challenges for the future include strengthening the focus on environmental sustainability, increasing the market share of inland navigation as a mode of transport, promoting technological progress and creating seamless freight connections in Europe.[4]

[1] Cf. World Wide Inland Navigation Network, URL: https://www.wwinn.org/the-rhine [12.05.2020].
[2] Cf. Zentralkommission der Rheinschifffahrt, URL: https://www.ccr-zkr.org/12000000-de.html [12.05.2020]; World Wide Inland Navigation Network, URL: https://www.wwinn.org/the-rhine [12.05.2020].
[3] Cf. World Wide Inland Navigation Network, URL: https://www.wwinn.org/the-rhine [12.05.2020].
[4] Cf.. World Wide Inland Navigation Network, URL: https://www.wwinn.org/the-rhine [12.05.2020].

2.2 Port of Rotterdam

The port of Rotterdam is the largest seaport in Europe, handling 465 million tons of cargo annually. In 2019, 14.8 million TEU (Twenty-Foot Equivalent Unit) containers passed through

the port of Rotterdam. The port area covers an area of 40 km and comprises 12,500 ha including land and water, and a commercial area of 6,000 ha. 30,000 seagoing vessels and 110,000 inland vessels pass through the port of Rotterdam every year. This indicates that the proximity of ports to urban areas is important to increase the use of inland waterways as a means of transport.[5]

2.3 Port of Duisburg

Duisport in Duisburg is the largest trimodal inland port in Europe with an annual turnover of more than 3 billion euros. The port connects water, rail and road transport and offers an industrial and logistics area of 14 million m². In 2019, 123.7 million tons of goods and 4 million TEUs were handled in the Port of Duisburg (including private company ports). 20,000 ships and 25,000 trains passed through the Port in 2019. Due to its favorable geographic location, Duisport offers connections to more than 80 destinations in Europe and Asia. Due to its extensive logistic know-how, various services such as container stuffing or stripping and pre-packing as well as services for industrial estates and real estate are offered.[6]

[5] Cf. Port of Rotterdam: Facts & figures about the port, online unter URL: https://www.portofrotterdam.com/en/the-port/facts-figures-about-the-port [24.04.2020].
[6] Cf. Duisport, online unter URL: http://www.duisport.de/en/ [24.04.2020].

Sources

viadonau (2019): Manual on Danube Navigation p 15-17
viadonau (2019): Manual on Danube Navigation p 20-21
viadonau (2019): Manual on Danube Navigation p 29
viadonau (2019): Manual on Danube Navigation p 38-83
viadonau (2019): Manual on Danube Navigation p 146-155
viadonau (2019): Manual on Danube Navigation p 161-163
World Wide Inland Navigation Network, URL: https://www.wwinn.org/the-rhine [12.05.2020].
Zentralkommission der Rheinschifffahrt, URL: https://www.ccr-zkr.org/12000000-de.html [12.05.2020]