Work Package 4: Infrastructure

Good Practice Manual on Inland Waterway Maintenance

Focus: Fairway maintenance of free-flowing rivers

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The complete list of participants of the PLATINA 2 expert group is given on page 162.

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1 Executive summary

The **quality and reliability of waterway infrastructure** is a key prerequisite for the competitiveness of inland navigation as a transport mode. Among several infrastructure elements, the **fairway** is one of the main aspects to consider in this respect. Tools to improve the quality and reliability of the fairway are available by means of structural interventions (“capital dredging”) and **regular maintenance and rehabilitation activities** (e.g. maintenance dredging or realignment of the fairway), each of them to be seen at the same level of importance.

Contrary to capital dredging, maintenance activities have received insufficient attention up to now. Their **potential for improving navigation conditions while safeguarding environmental requirements and saving cost** has not been leveraged. The strong need for improving maintenance activities on European waterways has also been underlined by the European Court of Auditors, who evaluated the implementation of inland navigation policy in Europe (EUROPEAN COURT OF AUDITORS 2015).

The document at hand represents a **guidance for waterway administrations in Europe improve their fairway maintenance processes**. The focus of the manual was set on *free-flowing river sections*, as these have been identified as one of the most critical issues (see Art.16 of the TEN-T Regulation; EUROPEAN COMMISSION 2013b: 12).

To provide such a guidance, the manual illustrates an **improved fairway maintenance cycle** that takes the processes beyond the actual implementation of a measure into account. These processes relate to monitoring the status of the fairway, planning the most suitable measures based on high-quality data, evaluating the impacts of measures and deriving possible improvements. Furthermore, informing of/communicating with the various actors involved in the appropriate manner is to be seen as a key element of such a cycle. The cycle is designed in a recurrent manner and to be seen as a **continuous improvement process**.

The manual also describes the related **proactive fairway maintenance strategy**, which aims at minimizing deterioration of navigation conditions as well as negative effects of interventions as much as possible through actions taken on beforehand to potential critical situations. Furthermore, this **integrative strategy** duly considers the **multiple functions of a waterway** and takes the requirement to act in compliance with the environmental regulatory framework into account.

To derive **recommendations for improved fairway maintenance** to be used by waterway administrations, **good practice examples** from several European waterway corridors have been collected and analysed. **Lessons learned** from these examples and requirements for implementation in other corridors are illustrated. That way, **knowledge exchange across corridors** shall be fostered.

The elaboration of the manual was supported by a European expert platform on waterway maintenance established within PLATINA 2 who provided input for and performed reviews of the draft manual. Topics that could not be covered in this document, but have been assessed as being in need of further discussion, are listed in the last chapter.

2 Background of the Good Practice Manual

The utilization of inland waterways strongly depends on the state of the physical infrastructure. Eliminating infrastructure bottlenecks of insufficient quality is a precondition for the competitiveness of inland waterway transport, as they determine the reliability and capacity of the waterway. In order to represent an attractive transport alternative for customers infrastructural bottlenecks need to be tackled with the highest priority. This task is, among other responsibilities, a key task of waterway administrations.

Such efforts may take the form of singular interventions (e.g. large river engineering projects) as well as rehabilitation and regular fairway maintenance activities. Up to now, some countries have set priorities on singular interventions, whereas recurring and continuous maintenance activities have often been set aside.

Over the last few years however, the potential of maintenance activities has been more and more recognized. The current TEN-T Regulation (EU No 1315/2013, Art. 15) requires Member States to ensure waterway maintenance so as "to preserve good navigation status" of waterways (EUROPEAN COMMISSION 2013b: 12). Furthermore, the 2015 Evaluation Report on European inland waterway transport strategies by the European Court of Auditors specifically stresses the importance of maintenance activities as non-performance reduces the effectiveness of waterway infrastructure projects and calls for improved implementation of related measures all over Europe (EUROPEAN COURT OF AUDITORS 2015: 8, 34).

In fact, effective and efficient regular waterway maintenance is a key issue to ensure economically and ecologically viable waterways. Proper maintenance results in stable or improved navigation conditions and prevents new bottlenecks that impede navigation. In addition, regular, targeted and comparably small-scale maintenance measures offer great potential to reduce negative effects on the ecosystem as well as on cost in comparison with larger interventions.

Waterway maintenance is a complex field. The responsible administrations face a variety of tasks and responsibilities, complex legal restrictions and diminishing resources. Any activities concerning the maintenance of inland and estuary waterways have to take the multi-functionality of natural waterways into account, such as hydropower generation, fishery, recreation, agriculture, public water supply, sewage clarification etc. As these uses often show conflicting interests, an integrative planning philosophy of waterway maintenance needs to be applied, aiming at achieving the necessary balance of all interests. Above all, any use of a river - including navigation - shall not have significant negative effects on its ecosystem, as a functioning ecosystem is a prerequisite for sustainable development.

In this context, initiatives to improve the efficiency and effectiveness of waterway maintenance in Europe need to be fostered, self-evidently in compliance with the existing regulatory framework. The Manual at hand is such an initiative, as it illustrates key projects and innovative approaches of waterway administrations from all over Europe and provides lessons learned that are useful for the practical work of a broader group of waterway administrations. The main input to the Manual was provided by a European Group of Experts on waterway maintenance, which was established under the EU co-funded project PLATINA 2. The experts selected projects from different waterway corridors in order to stimulate knowledge exchange between waterway administrations on a pan-European scale and to develop expert networks beyond national boundaries. Where needed, specific conditions of different waterway corridors were taken into account.

3 Objectives

3.1 Thematic focus

The focus of this Manual lies on **maintenance of the fairway**. The term "fairway" refers to that part of an inland waterway (rivers, lakes, canals) in which a targeted depth and width are maintained in order to enable continuous navigation[1]. The respective parameters of the fairway are harmonised on an international scale. The width and the course of the fairway are marked by internationally standardised fairway signs such as buoys or marks on the riverbank. The main measure of fairway maintenance is to keep the fairway in a "good navigable condition", according to the requirements of the current TEN-T Regulation EU No 1315/2013 ("TEN-T Guidelines").

Riverbanks and bridges may limit fairway parameters but are not part of it and thus are not the focus of this Manual. River engineering structures like groynes or training walls however, while not being part of the fairway either, serve the purpose of directing the water flow towards the fairway, especially in low-water periods. In this way they strongly influence fairway conditions like a river section's flow velocity or its water depth and thus will be taken into account in specific chapters.

The depth of the fairway influences the possible draught of an inland vessel and thus the amount of cargo it can transport. Furthermore, the dynamic squat and a sufficient under keel clearance to the riverbed have to be considered to prevent groundings of vessels in motion (see Figure 1). The term "squat" refers to the level to which a ship sinks while it is in motion as compared to its stationary condition. The dive depth of a ship equals the sum of its draught loaded (loaded vessels in stasis; velocity v = 0) and its squat (loaded vessel in motion; velocity v > 0) (VIA DONAU – AUSTRIAN WATERWAY COMPANY 2013: 51).

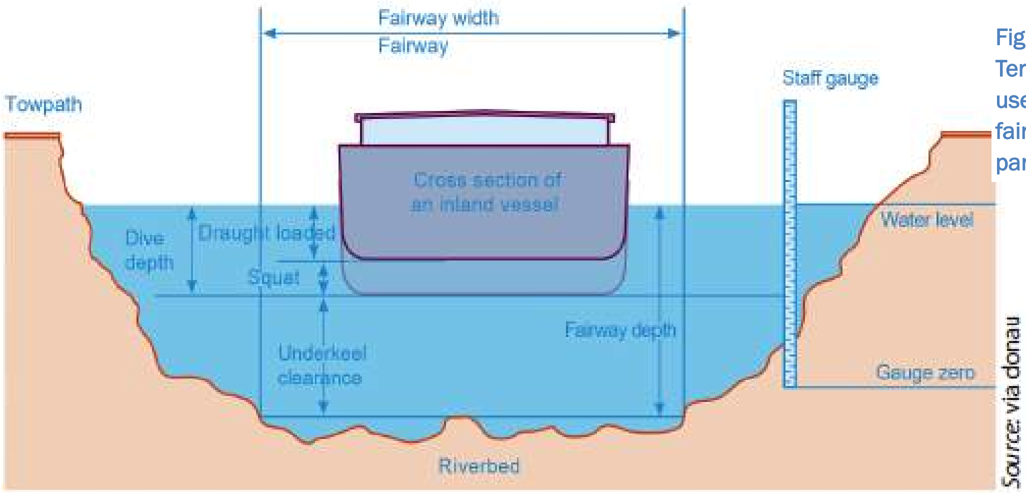

Figure 1: Terminology used for fairway parameters

[1] The CCNR Sécretariat proposed the following terminology for harmonisation across several languages (CCNR 2016):

	DE	NL	FR	EN
1.	Wasserstraße	Vaarweg	Voie d'eau	Waterway
2.	Fahrwasser	Vaarwater	Bande navigable/Eau navigable	Fairway
3.	Fahrrinne	Vaargeul	Chenal navigable	Navigable channel

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Fairway maintenance measures are seen as **recurring, short-term measures for providing harmonised infrastructure parameters along the transport corridors**, specifically a certain width and depth of the fairway on a specific waterway section which falls short of showing the targeted fairway parameters. Within the scope of the Manual, this mainly relates to, on the one hand, regular dredging activities and, on the other, to shifting the course of the fairway by means of repositioning of floating signs (buoys, spears, etc.). However, these activities are embedded in a more extensive process that comprises monitoring, planning, executing, evaluating and informing (see Chapter 6). Measures that increase the efficiency and effectiveness of the process and keep the negative influence of fairway interventions as low as possible are considered as Good Practices Examples.

Fairway maintenance measures are an essential supplement to structural (i.e. river engineering) interventions, which are usually executed in a restricted time frame, but with regard to their effects are mid- and long-term oriented. River engineering structures for low-water regulation upgrade or extend a waterway. When designing interventions, the interplay between these two types of measures should be taken into account.

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Figure 2: Maintenance works and groyne adaption on the Austrian stretch of the Danube (free-flowing sections Wachau and east of Vienna)

The Manual mainly addresses **navigational maintenance.** Services pursuing exclusively ecological objectives or measures which are not linked to navigation are not subject of this document. However, it is emphasized that safeguarding environmental objectives is a general and key prerequisite of the maintenance process. Each and every maintenance measure must be planned and implemented as environmentally sound as possible (see Chapter 6) and in compliance with European and national legislation as well as further voluntary agreements and strategies, if applicable.

Furthermore, this Manual concentrates on maintenance of **free-flowing sections of natural waterways** (rivers), based on the fact that the TEN-T Regulation, in its Article 16, calls for "paying particular attention to free-flowing rivers which are close to their natural state and which can therefore be the subject of specific measures" (EUROPEAN COMMISSION 2013b: 12).

However, there is no commonly agreed definition of "free-flowing" rivers or river sections. Also the TEN-T Guidelines do not go beyond the expression "being close to its natural state". The World Wide Fund for Nature (WWF) provides a more detailed specification: A "free-flowing" river is "any river that flows undisturbed from its source to its mouth [...], without encountering any dams, weirs or barrages and without being hemmed in by dykes or levees" (WWF GLOBAL FRESHWATER PROGRAMME 2006: 1). As in reality such rivers are very rare, this Manual concentrates on "free-flowing river sections" and defines them as sections of natural rivers which are not impounded due to barrages such as hydropower plants or lock facilities and where water levels can be subject to considerable fluctuations[2]. Free-flowing river sections might of course include river engineering structures for low-water regulation (e.g. groynes and training walls) and/or flood protection structures along their banks.

These river sections show specific characteristics and pose a challenge for navigation. The flow velocity in free-flowing sections is usually higher than in impounded sections, artificial canals or lakes. This leads to a more dynamic transport of sediments, especially in periods with higher water levels and corresponding higher flow velocities. Along with the respective discharge of a river, transport sediment leads to a continuous change in the morphology of the riverbed, either in the form of sedimentation or erosion. Especially in shallow or narrow river sections this continuous change of the riverbed can lead to restrictions for navigation with regard to the minimum fairway parameters (depth and width) that are to be maintained by waterway administrations.

Furthermore, particular attention is needed regarding the interplay between navigation and ecological requirements in free-flowing sections, as these are closer to their natural state and thus still provide greater ecological value than impounded sections or artificial rivers and canals. In addition, such river sections are often a part of dedicated Protected Areas (Natura 2000 network of Special Areas of Conservation and Special Protection Areas designated under the EU Habitats Directive and the Birds Directive). Accordingly, measures need to be developed and implemented with great care in order to preserve ecological quality as much as possible, respecting the applicable environmental law. In general, all water bodies are covered by the requirements of the Water Framework Directive, even if they lie in areas outside of nature conservation areas. This is particularly important regarding the principle of preventing deterioration and regarding the achievement of the Water Framework Directive objectives.

This Manual has a broad scope and does not specifically focus on the interplay of ecology and navigation, as this would require further in-depth analysis of specific issues. However, environmental requirements need to be embedded in all individual projects and measures taken in rivers must of course be enacted within the legal framework - environmental regulations like the EU Water Framework Directive (2000/60/EC) and the EU Birds and Habitats Directives (Natura 2000 network, 2009/147/EC and 92/43/EEC). Due to this, these related issues will be taken into account in the Manual, where necessary (see, e.g., Chapter 6.3).

Additional aspects in need of discussion that are not within the scope of the Manual at hand are listed in chapter 9.

3.2 Objectives of the Manual

The Manual has been prepared to **support waterway administrations in their daily work of fairway maintenance**. It also illustrates the tasks and challenges of waterway administrations towards further parties in the process (e.g. waterway users) and should help to improve common understanding and communication. Consequently, the objectives of this Manual are:

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[2] This definition has been elaborated for the purpose of this document. It was not based on any specific existing definition.

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1. To describe an improved, i.e. efficient and effective, fairway maintenance process for waterway administrations in Europe.

2. To illustrate further practical approaches and good practices from the major fields of the maintenance cycle (see Chapter 7) to foster pan-European knowledge exchange.

3. To derive lessons learned and practical guidelines for waterway administrations.

3.3 Structure and content

In Chapter 5, international and waterway corridor-related fairway maintenance targets – legally binding as well as voluntary - are elaborated. Starting from this basis, the Manual explains strategies to plan and implement improved fairway maintenance facing limited financial resources on the side of waterway administrations and demands arising from further functions of a river. The Manual addresses how these can be integrated into the planning process and tackled through an integrative corridor-oriented, cross-border planning approach (Chapter 6). The various steps of planning measures are thoroughly described in Chapter 7 via the continuous fairway maintenance process, a recurring cycle comprising status monitoring, planning, executing and evaluating measures. The improved fairway maintenance process is illustrated by selected practice examples from all of these fields.

Where possible and meaningful, the lessons learned from these Good Practice Examples were abstracted in order to be beneficial to a broader group of European waterway administrations and waterway corridors. General guidelines based on the discussion process accompanying the elaboration of the Manual are given in Chapter 8.

Further topics that have been identified to be in need of discussion by the Group of Experts are listed in Annex 11.1.

In addition, a glossary to foster a common understanding of essential terms was prepared (see Annex 11.2).

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4 Method of elaboration

4.1 Expert Group on waterway maintenance

This Manual was developed within the framework of PLATINA 2[3] and was supported by a European Group of Experts in waterway maintenance. Selected experts from 11 European waterway administrations and two river commissions[4] staffed the group and discussed specific issues closely related to implementation of fairway maintenance. On the one hand, the Group established a common understanding of the framework conditions, key issues and chosen waterway management approaches in the different waterway administrations and corridors, while on the other hand, practical examples out of the fairway maintenance process were analysed and discussed.

The Expert Group provided content-related steering for this document by carefully choosing the topics and examples to be dealt with, as well as discussing and proofreading the Manual. Additional output of the group work (terms of reference, meeting minutes, discussion papers, presentations, etc.) is provided on www.naiades.info. As already mentioned, outlines for further topical work beyond the scope of this Manual are provided in Annex 11.1.

4.2 Overview of addressed river sections

The main navigable rivers and canals for inland waterway transport (IWT) in Europe are the Rhine, the Meuse, the Albert Canal, the Scheldt, the Seine, the Rhône, the Elbe, the Mittellandkanal, the Moselle, the Main, the Main-Danube Canal and the Danube. The IWT sector, transporting around 140 billion ton-kilometres per year, considerably contributes to the EU's transport performance.

The Rhine IWT sector is by far the most dominant and mature market, with a share of almost 70% in total transport performance in the EU (about 90 billion ton-kilometres in 2010). On the Danube, the second biggest transport axis in Europe, about a third of this amount is transported (approximately 26 billion ton-kilometres in 2010). Due to these basic conditions, waterway maintenance experts from the Rhine and the Danube region were strongly represented in the Expert Group. Experts from other river corridors comprising free-flowing sections complemented them: the Scheldt, the Elbe and the Sava, which is a navigable tributary of the Danube river.

The Good Practice Examples illustrated in the Manual were provided by the Expert Group members and are covering the Upper, Middle and Lower (not maritime) Danube, the free-flowing sections of the Rhine and the tidal Scheldt (see Figure 3 below and Chapter 4.3).

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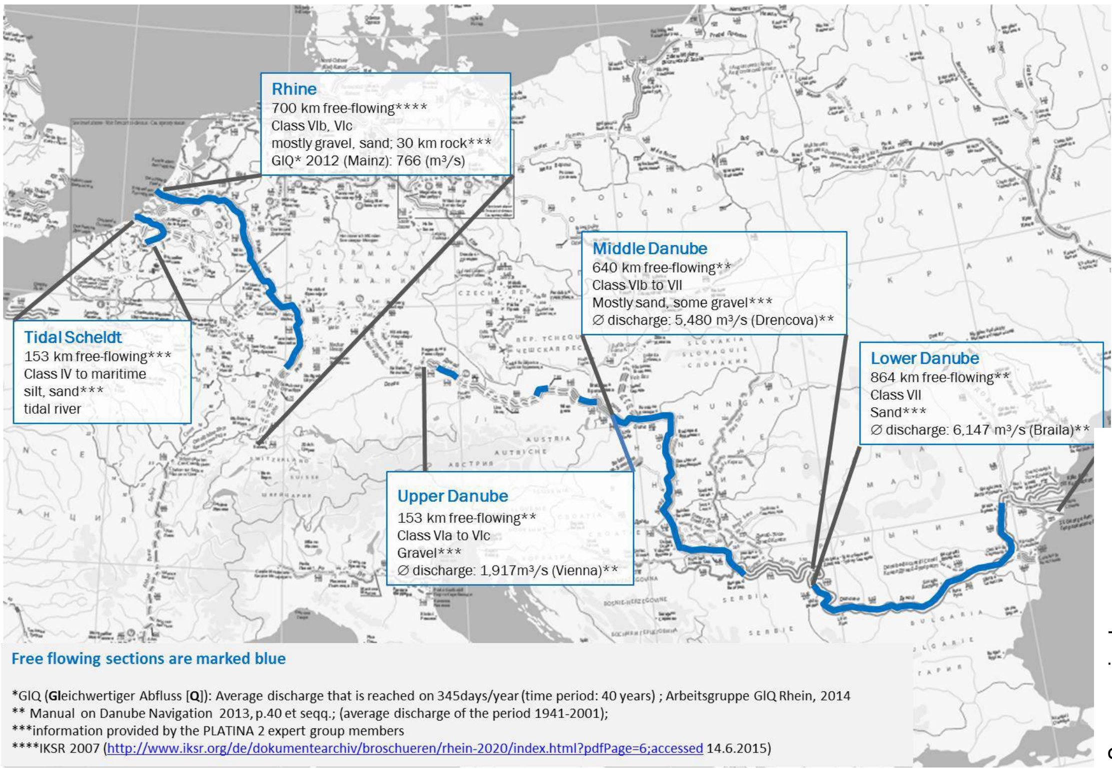
[3] PLATINA 2 (2013 – 2016) is a European Coordination Action supporting the implementation of the EU's NAIADES 2 policy package "Towards quality inland waterway transport", which aims at promoting this sustainable mode of transport.

4 See Annex 1.1 for a list of the contributing administrations/river commissions/persons. The members originate from France, Belgium, The Netherlands, Germany, Austria, Slovakia, the Czech Republic, Serbia, Romania, the Danube Commission, the Sava Commission.



Source: via donau

Figure 3: Free-flowing waterway sections addressed in this Manual

4.2.1 The Rhine

On 883 kilometres, the Rhine is navigable as a class VIb or VIc waterway, according to the CEMT/UNECE classification of European inland waterways (see Chapter 5.2). Out of the navigable part, 530 km are free-flowing. While the riverbed mostly consists of gravel and sand, the main critical section for navigation, i.e. from river-km 528 to 557 (the so-called "Gebirgsstrecke"), has a rocky bottom and reaches a fairway depth of only 1.90 m in relation to the equivalent water level or GIW[5]. On the Rhine, low water periods usually occur between September and November but may vary. An average amount of 300,000 m^3 of sediment needs to be dredged annually in the course of fairway maintenance measures[6].

4.2.2 The Scheldt

The Scheldt is a 350 km long river with ECMT waterway classes from IV to maritime. It has the Port of Antwerp, the second largest port in Europe, on its banks. A rather unique characteristic of the Scheldt is the influence of the tide on the free-flowing waterway. Being connected to the North Sea, the tidal range can reach up to six metres, depending on the location and the time of the day. This has an undeniable influence on the appearance of critical locations. The riverbed consists of silt and

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5 The "Gleichwertiger Wasserstand (GIW)" or "equivalent water level" is a corresponding water level at different cross sections of a river with the same period of higher and lower deviation.

6 The annual values were provided by the Expert Group members. For the Danube, the values were taken from the Danube Fairway Rehabilitation and Maintenance Roadmaps of June 2015.

sand, which is at times polluted by metals. Low water upstream discharge periods usually occur in the summer months. Approximately 150,000 m³ are dredged annually.

4.2.3 The Danube

The Danube shows waterway classes from Va to VII. Due to its high gradient, the Upper Danube shows the characteristics of a mountain river, while after the change of gradient at Gönyű in northern Hungary, the river becomes a lowland river. About 70% of the 2,415 km long, navigable Danube are free-flowing sections. Most of the hydroelectric power stations are situated at the steeper Upper Danube where most river sections are impounded. On the Central and Lower Danube free-flowing sections are predominant. On the Upper and Middle Danube, the riverbed mainly consists of gravel, turning into sandy gravel and finally sand towards the Danube delta. Low water periods usually occur between October and February. The gradient of about 37 cm per km at the Upper Danube results in outstandingly high volumes of sediment transport. On the whole Danube, an estimated amount of about 1,400,000 m³ are to be dredged annually.

4.3 Overview of Good Practice Examples

17 Good Practice Examples have been identified by the members of the Expert Group and are illustrated in this Manual:

	Area/Country River	Name	Topic	Chapter & Page No.	
A	Rhine Corridor	**Coordination of maintenance works on the Rhine**	Corridor-oriented and coordinated definition/illustration of waterway targets	4.3 – Corridor-oriented targets	22
B	Serbia – Danube	**Establishing fairway parameters on the basis of levels of service**	Definition and implementation of levels of service to establish fairway continuity	5.2.2 – Levels of Service for fairway maintenance	37
C	Danube Corridor	**Common minimum level of service for waterway management**	Definition of a common minimum level of service and corresponding performance indicators	5.2.2 – Levels of Service for fairway maintenance	41
D	Germany	**Framework Concept for Maintenance ("Rahmenkonzept Unterhaltung")**	Multi-disciplinary approach in integrated maintenance planning	6.3.3 – Integrated planning approaches	60
E	Belgium – Sea Scheldt	**Sustainable maintenance plan for the Upper Sea Scheldt**	Multi-disciplinary approach in integrated maintenance planning	6.3.3 – Integrated planning approaches	62

	Area/Country River	Name	Topic	Chapter & Page No.	
F	DE/NL – Rhine	**Stabilisation of the Rhine riverbed along the state border**	Corridor-oriented, cross-border planning approach	6.3.4 – Corridor-oriented approaches	65
G	BG, HR, RO, RS – Danube	**Corridor-oriented fairway marking database**	Cross-border monitoring of fairway marks and harmonising information	7.1.3 – Fairway marking: monitoring of fairway marking	81
H	Austria – Danube	**Multiannual framework contracts for dredging services**	Reducing lead time for outsourced maintenance dredging works	7.2.1 – Choice of measures	94
I	Austria – Danube	**Development and implementation of a computer-assisted waterway management system**	Software development for waterway maintenance management	7.2.2 – Computer-assisted waterway management tools	100
J	Germany	**Instruction for the handling of dredged material of inland sediments (HABAB 2000)**	Guidelines for execution of dredging measures	7.3.1 – Fairway maintenance dredging	107
K	DE/FR – Rhine	**Artificial bed load supply at Iffezheim**	Description of a bed load supply project under implementation	7.3.1 – Fairway maintenance dredging	111
L	Serbia – Danube	**Responsive fairway realignment and fairway information**	Selection of operational measures and the impact on fairway availability	7.3.2 – Fairway relocation	118
M	Germany	**ELWIS – Electronic Waterway Information Service**	Comprehensive web portal for publication of waterway-related data	7.5.1 – User information	129
N	Danube Corridor	**Bottleneck information on the Danube FIS Portal**	Fairway information services for the Danube waterway	7.5.1 – User information	129
O	Austria – Danube	**Navigability analysis of the Danube**	Long-term statistical analysis of water levels enable more efficient use of vessel loading capacity	7.5.1 – User information	132
P	France	**Regular user committees on national and local level**	Structured process to get user feedback on the quality of nautical services	7.5.2 – User integration	134

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	Area/Country River	Name	Topic	Chapter & Page No.	
Q	The Netherlands	**User surveys on services of the National Waterway Administration**	Structured process to get user feedback on the quality of nautical services	7.5.2 – User integration	137
Country abbreviations: BG = Bulgaria, DE = Germany, FR = France, HR = Croatia, NL = The Netherlands, RO = Romania, RS = Serbia					

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5 Fairway maintenance targets

The general goal of fairway maintenance is the provision of optimal fairway conditions for inland navigation, especially in low-water periods, based on an effective use of available resources. Waterway management authorities are operating under several international agreements and recommendations regarding the targeted fairway parameters (width, depth and vertical clearance under bridges and overhead cables).

Such targets are set by international regulations and agreements. Among these are the Trans-European Transport Network (TEN-T) Regulation, the Agreement on Main Inland Waterways of International Importance (AGN), the Recommendations of the European Conference of Ministers of Transport (ECMT), the Mannheim Convention (Rhine) or the Belgrade Convention (Danube). Some waterway administrations take additional targets into account which derive from national/regional regulations and/or recommendations.

However, the main waterway-related targets which are of legally obligatory character on the pan-European level are represented by the following documents:

1. The EU's Trans-European Transport Network (TEN-T) guidelines in Regulation (EU) No 1315/2013.

2. The UNECE's European Agreement on Main Inland Waterways of International Importance (AGN), 1996.

Whether these targets may be achieved, depends on a number of factors which are, to a certain extent, beyond the range of influence of waterway authorities (e.g. discharge and corresponding water levels during the year, navigation closures e.g. due to ice or accidents, available budgets for operational maintenance measures, or political decisions, etc.).

5.1 Requirements based on the TEN-T Regulation

In Articles 15 and 39 of the **TEN-T Regulation (EU) No 1315/2013 on Union Guidelines for the Development of the Trans-European Transport Network** the minimum inland waterway infrastructure requirements for core network[7] inland waterways are described. The Member States have to comply to these requirements by 31 December 2030:

TEN-T Regulation (EU) No 1315/2013

Article 15: Inland waterway transport infrastructure requirements for the Comprehensive Network

1. Member States shall ensure that inland ports are **connected with the road or rail infrastructure**.

2. Inland ports shall offer **at least one freight terminal** open to all operators in a **non-discriminatory** way and shall apply transparent charges.

3. Member States shall ensure that:

[7] The core transport network to be established by 2030 acts as the backbone for transportation within the EU's Single Market; it is supported by a comprehensive network of routes, feeding into the core network at regional and national level.

(a) rivers, canals and lakes comply with the **minimum requirements for class IV waterways** as laid down in the new classification of inland waterways established by the European Conference of Ministers of Transport (ECMT) and that there is **continuous bridge clearance**, without prejudice to Articles 35 and 36 of this Regulation.

At the request of a Member State, in duly justified cases, exemptions shall be granted by the Commission from the minimum requirements on draught (less than 2,50 m) and on minimum height under bridges (less than 5,25 m);

(b) rivers, canals and lakes are maintained so as to **preserve good navigation status**, while respecting the applicable environmental law;

(c) rivers, canals and lakes are equipped with **RIS**.

Article 15.3 (b) calls on Member States to preserve a "**good navigation status**" on their core network corridor waterways. This particularly relates to waterway maintenance. However, the concept of the "good navigation status" is not specified any further, with the exception of the basic targets of 2.5 m vessel draught and a minimum height under bridges of 5.25 m. However, as of 2016, a study initiated by the European Commission is expected to further specify this concept for a possible revision of the TEN-T Regulation. The PLATINA 2 Group of Experts advises that the following guidelines should be taken into account in the definition process:

- Base the specification of parameters and target values on a corridor approach.
- Take existing (inter-)national frameworks as basis for the definition.
- Define a base reference duration in days per year on which parameters and target values should be reached for free-flowing stretches of natural rivers and for estuary rivers which are characterized by frequently fluctuating water levels.
- Include requirements for fairways as well as related infrastructures (locks, bridges, etc.) in the definition.
- Consider hydro-morphological and other limitations for the definition of parameters on the basis of which exceptions from the minimum TEN-T requirements may be granted.
- Take aspects of traffic management (taking the RIS Guidelines as basis) into account.
- Give information to the fairway users (taking the RIS Guidelines as basis), including hydrographical and hydrological services and restrictions due to works and how these are agreed and coordinated with fairway users and/or other administrations.

5.2 Requirements based on the AGN Agreement

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). The Agreement came into force in 1999. It constitutes an international legal framework for the planning of the development and maintenance of the European inland waterway network and ports of international importance. It is based on technical characteristics and operational criteria for inland waterways (specified in Annex III of the Agreement).

AGN, ECE/TRANS/120/Rev.2, 19 January 1996

Annex III: Technical and operational characteristics of inland waterways of international importance

(a) Technical characteristics of E waterways

The main technical characteristics of E waterways shall generally be in conformity with the classification of European inland waterways set out in Table 1 [see Figure 4].

For the evaluation of different E waterways, the characteristics of classes IV – VII are to be used, taking account of the following principles:

(ii) Only waterways meeting at least the basic requirements of class IV (minimum dimensions of vessels 80 m x 9.5 m) can be considered as E waterways. Restrictions of draught (less than 2.50 m) and of minimum height under bridges (less than 5.25 m) can be accepted only for existing waterways and as an exception;

(viii) On waterways with fluctuating water levels, the value of the recommended draught should correspond to the draught reached or exceeded for 240 days on average per year (or for 60% of the navigation period).[3/] The value of the recommended height under bridges (5.25, 7.00 or 9.10 m) should be ensured over the highest navigation level, where possible and economically reasonable;

3/ However, for upstream sections of natural rivers characterized by frequently fluctuating water levels due to strong direct dependence of weather conditions, it is recommended to refer to a period of at least 300 days on average per year.

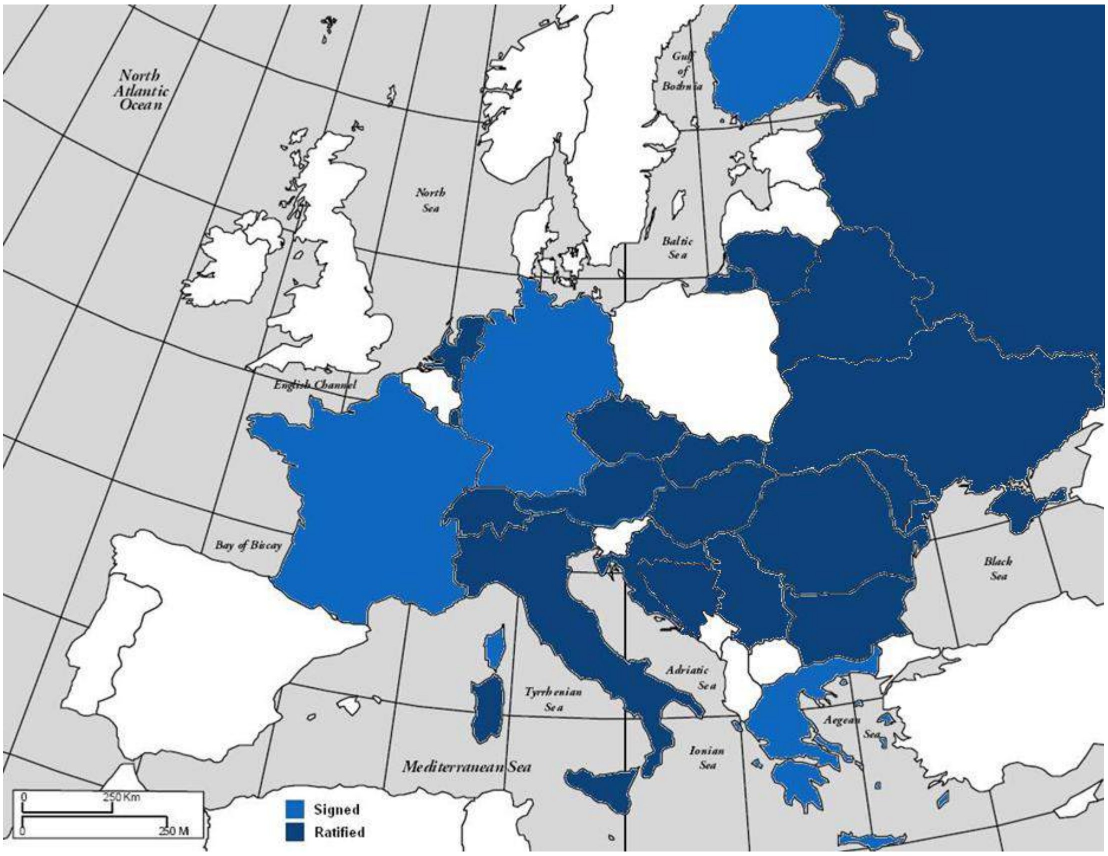
To date, the AGN comprises 18 contracting parties (on the basis of ratification, acceptance, approval or accession)[8]. In accordance with article 5.1, the Agreement is open for signature by States which are members of the United Nations Economic Commission for Europe or have been admitted to the Commission in a consultative capacity.

The current contracting parties to the AGN are (in alphabetical order, with kind of conclusion of the agreement provided in brackets): Austria (ratification), Belarus (accession), Bosnia and Herzegovina (accession), Bulgaria (accession), Croatia (acceptance), Czech Republic (approval), Hungary (ratification), Italy (ratification), Lithuania (ratification), Luxembourg (ratification), Moldova (ratification), Netherlands (ratification), Romania (ratification), Russian Federation (approval), Serbia (accession), Slovakia (approval), Switzerland (ratification), and Ukraine (accession) (see Figure 4).

Four other European countries have signed the Agreement, but are not contracting parties and thus not legally bound to the provisions of the AGN. These countries are (in alphabetical order): Finland, France, Germany and Greece.

In 1998, the UNECE Inland Transport Committee published an "Inventory of Main Standards and Parameters of the E Waterway Network", the so-called "**Blue Book**", as a supplement to the AGN. The document 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 in the network. This publication enables monitoring of the current state of implementation of the Agreement on an international basis.

8 http://www.unece.org/trans/conventn/legalinst_06_TINF_AGN.html (accessed on 30 October 2015).



Source: UNECE; © via donau

Figure 4: AGN contracting parties and signatory states (as of October 2014)

Among the technical characteristics of the AGN waterway network is a **classification of European inland and coastal waterways according to waterway classes** which are identified by Roman numbers from I to VII. Waterways of class IV or higher are of economic importance to international cargo transport (so-called "E waterways"). Classes I to III identify waterways of regional and national importance ("recreational waterway network"). The class of a specific inland waterway is determined by the maximum dimensions of the commercial vessels which are able to operate on it. Decisive factors in this respect are the width and length of inland vessels and convoys, as they constitute fixed reference parameters (see Figure 5).

The classification of European inland waterways was first introduced by the European Conference of Ministers of Transport (ECMT) (Fench: Conférence Européenne des Ministres des Transports – CEMT) in 1954. A first revised edition was published as ECMT Resolution No. 8 on 21 November 1961, the second revised edition was adopted by both ECMT and the UNO in Geneva as Resolution No. 92/2 in 1992. The 1992 ECMT Resolution corresponds to the classification of European inland waterways of international importance which is part of the AGN (Annex III) in most parts.

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Motor cargo vessels						
Type of vessel: general characteristics						
Water-way class	Designation	Max. length L (m)	Max. width B (m)	Draught d (m)	Deadweight T (t)	Min. height under brideges 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

Pushed convoys						
Typ of convoys: general characteristics						
Water-way class	Formation	Length L (m)	Width B (m)	Draught d (m)	Deadweight T (t)	Min. height under brideges 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

Figure 5: Waterway classes according to ECMT/UNECE (2010)

5.3 Corridor-oriented targets

In addition to the pan-European framework, specific targets and indicators have been defined for several waterway corridors, taking the regional and local conditions into account.

A forerunner in this respect is the Central Commission for Navigation of the Rhine (CCNR), which has been coordinating overarching targets and measures to promote inland navigation in the **Rhine Corridor** in close cooperation with the riparian states since 1815 (www.ccr-zkr.org). Its legal foundation is the Revised Convention for Navigation on the Rhine – referred to as the Mannheim Convention of 17 October 1868.

The CCNR has competences in many areas of inland navigation. In the field of infrastructure, the Central Commission has established the Committee for Infrastructure and Environment (IEN) which, among other activities, monitors all works on the Rhine that might affect navigation, determines the equivalent water level, and monitors the implementation of the WFD and the FFH Directive. This successful and well-practiced system is regarded as "Good Practice". The targets pursued relevant for waterway infrastructure are the waterway classes of ECMT (see Chapter 5.2).

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A) COORDINATION OF MAINTENANCE WORKS ON THE RIVER RHINE

Rhine

Rhine Corridor

Problem/topic

Works on a river may have wide-spread effects such as causing obstacles for shipping, disturbing the river's discharge and sediment regime or waterway blockings. On an international waterway like the Rhine, these effects are often relevant for more riparian states than the one implementing the measure, which could lead to critical situations if not well coordinated.

Objectives

In order to minimize negative effects of works in or along the Rhine and to coordinate the further development of the waterway infrastructure, the Central Commission for Navigation on the Rhine (CCNR) has established an efficient, compulsory transnational coordination process.

Background information

The Central Commission of the Rhine ("CCNR") finds its basis in the "Mannheimer Akte/Revidierte Rheinschifffahrtsakte" of 1868. It is an international organisation comprising the five Member States Germany, Belgium, France, The Netherlands and Switzerland, which are supported by a Secretariat. The Central Commission was created to ensure the freedom of navigation on the Rhine to ensure prosperity of navigation and a high level of safety for navigation and its environment. Cooperation is enacted with 11 European Observer States, other river commissions and international bodies.

The Member States of the CCNR draw up resolutions which must be adopted by their members via unanimous vote during plenary meetings (usually 2 times a year). The resolutions are binding on its Member States. The plenary meeting's resolutions are prepared by dedicated committees and working parties.

Further rights and duties of several states regarding the Rhine as waterway are ruled in the Treaty of Versailles (Versailler Vertrag), "Vertrag zwischen der Bundesrepublik Deutschland und der Französischen Republik über den Ausbau des Oberrheins zwischen Basel und Strasbourg" (1956) and "Vertrag über den Ausbau des Rheins zwischen Kehl/Straßburg und Neuburgweier/Lauterburg" (1969).

The waterway classes of the Rhine and thus the targeted waterway-related parameters are defined by the standards of the European Conference of Ministers of Transport (ECMT) in 1992 (ECMT classes). The Rhine riparian states have adopted these standards.

Description of activities

Articles 28 and 29 of Mannheimer Akte require that states sharing their borders along the bank of the Rhine exchange information of construction and maintenance projects which may affect shipping conditions. This exchange takes place within the dedicated "Committee for infrastructure and environment" (IEN) which it is assisted by its specialised Working Group (IEN/G).

The work of the committees and working groups are prepared by the Secretariat and the national delegations. Further stakeholders (e.g. observer states, industry representatives) may take part as well.

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A) COORDINATION OF MAINTENANCE WORKS ON THE RIVER RHINE

Rhine

Rhine Corridor

Activities of the Committee for infrastructure and environment (IEN) are:

- Monitor, analyse and discuss any works on the Rhine which might affect navigation,
- Investigate navigation incidents with respect to how they might be related to the waterway infrastructure
- Monitor implementation for the Rhine of the Water Framework Directive and the Habitats Directives. Monitor the list of Natura 2000 zones affecting the Rhine waterway;
- Participate in activities to prevent significant negative impact on navigation in the context of implementing the FFH and WF Directives.
- Cooperate with the ICPR (International Commission for the Protection of the Rhine)
- Monitor the physical characteristics of the waterway Rhine: Bridge heights and vertical clearance, navigation channel profile
- Monitor works carried out on locks, bridges and other waterway-related infrastructure
- Assess navigation on the Rhine with respect to effects of climate change
- Analyse interruptions of navigation and propose measures adopted to reduce them
- Determine equivalent water level
- Deal with cross-cutting issues related to the environment as well as basic questions concerning the sustainable development of inland navigation

The Member States are obliged to inform the CCNR about construction and major maintenance projects on the river. The activities are examined concerning their effects on the waterway system during the meetings of the Committee and Working Group on Infrastructure and Environment which usually meet twice a year. The Central Commission has also agreed on minimum requirements and recommendations for the technical design of structures along the Rhine, which serve to evaluate construction and maintenance measures and as criteria for decisions on approving structures along the Rhine. After discussion in the committee, the measures that have been identified as affecting navigation significantly need to be approved unanimously during the CCNR Plenary Session. This procedure ensures that plans and progress of all construction and major maintenance projects are collected, discussed and agreed on centrally. The examination of the projects and their approval by the Central Commission follow standardised and agreed upon procedures.

The CCNR compiles the data and publishes it on its website. Furthermore, a graphic is produced ("Navigation channel profile") showing the main parameters of the waterway between Basel and Rotterdam (see Figure 6).

The "waterway profile" of the Rhine provides information on the air draught at highest navigable water level and the fairway depth and width at equivalent water level along the Rhine between Basel and Rotterdam (river-km 166 to river-km 952/955). In case of short-term restrictions of fairway parameters, there are several web portals on which users can get the necessary information (e.g. Avisbat (Voies Navigable France), Vaarweginformatie (Rijkswaterstaat) or the German ELWIS system see Good Practice Example M in Chapter 7.5.1).

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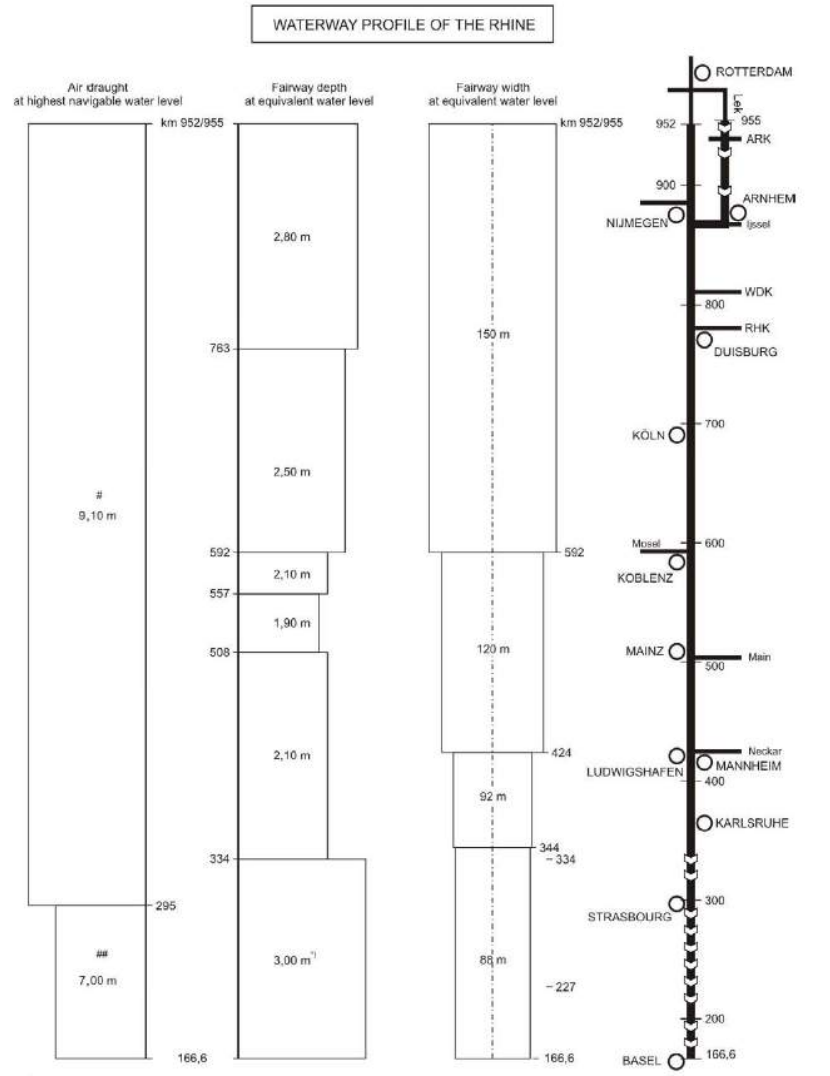
A) COORDINATION OF MAINTENANCE WORKS ON THE RIVER RHINE

Rhine

Rhine Corridor



Source: Central Commission for Navigation of the Rhine

Figure 6: Longitudinal waterway profile of the Rhine

Users and stakeholders

Directly involved in the coordination process:

- CCNR Member States: Germany, France, The Netherlands and Switzerland;As it is not a riparian state, Belgium as a CCNR Member State is usually not involved in CCNR activities regarding waterway infrastructure;
- The CCNR "Committee on infrastructure and environment" and its working group and discussion platforms/working bodies and the CCNR Plenary Session as deciding panel. The CCNR Member States are represented in all these bodies.

A) COORDINATION OF MAINTENANCE WORKS ON THE RIVER RHINE	Rhine Rhine Corridor

- The CCNR Secretariat as supporting body.

If necessary, cooperation is enacted with:

- CCNR Observer States: Austria, Bulgaria, Luxembourg, Hungary, Poland, the Czech Republic, Republic of Serbia, the Slovak Republic, Romania, the United Kingdom, Ukraine.
- European Commission, UNECE
- River Commissions for the Danube, Moselle and the Sava, International Commission for the Protection of the Rhine
- External experts, environmental stakeholders, industry representatives

Key success factors and innovative aspects

The exchange of information between the riparian states coordinated by the CCNR has a long tradition and is ruled by several treaties. There is a legal obligation to exchange information on planned and ongoing works, and the procedures that regulate this exchange have proven to be efficient. The established communication structures secure close and effective integration of the national delegations, representatives of the industry, external experts and the CCNR Secretariat.

Furthermore, most of the projects of the committees and working parties are drawn up on the basis of consensus, which makes effective decision-making possible despite the unanimity rule that applies to the plenary meeting.

A key success factor is also the coordinated illustration of fairway parameters via the waterway profile. The profile is updated if necessary.

Time frame and status

This process of finding consensus has been effective since adoption of the Mannheim Convention in 1868 until today. Two meetings of the Committee and two working group meetings take place per year and may be convened more frequently, if necessary. The Plenary Sessions take place twice a year. Plans of measures are usually made for a period of two years.

Lessons learned

Complex interaction needs agreed upon and standardised processes. Reaching consensus and establishing coordinated work plans across national boundaries can benefit from a solid legal basis. However, an efficient central body, a strong wish for cross border cooperation and mutual trust seem to be the main success factor of such cooperation.

Integrating all relevant stakeholders at the right stage is a key prerequisite as well. The Rhine is a good example for an existing and functional cooperation.

In addition, the waterway profile graphic has proven useful as coordinated and clear display of the general shipping conditions along the Rhine.

Requirements for implementation in other Member States

The legal set-up of such a coordinating system is dependent on the specific legal conditions of the affected states. No direct transfer of this system developed by the CCNR is possible. However, a

A) COORDINATION OF MAINTENANCE WORKS ON THE RIVER RHINE	Rhine Rhine Corridor
regulated process of mutual information by the Member States, joint discussion and joint adoption of activities in order to implement the best measures from a systematic viewpoint is recommended, regardless of their political systems and financial status.	
Further information/contact	
www.ccr-zkr.org	

In the **Danube Corridor**, the "Convention Regarding the Regime of Navigation on the Danube" ("Belgrade Convention") was signed by all Danube riparian states in 1948 with the main goals to safeguard the freedom of navigation on the Danube for all states and to oblige the Danube states to maintain their sections of the Danube waterway in a navigable condition. The implementation of the Convention is monitored by the Danube Commission (www.danubecommission.org).

The waterway infrastructure related targets pursued in the Danube Corridor are based on CEMT/UNECE waterway classes (see Chapter 5.2). In addition, the Danube Commission (DC) issued the "Recommendations on Minimum Requirements for Standard Fairway Parameters, Hydrotechnical and Other Improvements on the Danube" in 1988 and 2013, respectively. In the first, a minimum fairway depth of 2.5 m below low navigation and regulation level (LNRL) is required. In the latter document the Danube Commission set a minimum of 2.5 m draught of loaded vessels below LNRL. Both definitions do not apply on the maritime stretch of the Danube (river-km 170.00 – 0.00). LNRL refers to the water level established for the navigable part of the Danube from Kelheim to Sulina and determined with duration of 94%, based on the discharges observed during a period of 30 years, excluding ice periods. Additionally, in its 2013 Recommendations the DC set a minimum fairway width of 50–180 m, depending on the site-specific characteristics of the river section.

Recently, joint objectives and indicators that cover all dimensions of fairway maintenance were developed for the Danube and its navigable tributaries (see Good Practice Example C on Common minimum level of service for waterway management, see Chapter 6.2.2). As a consecutive step, the "Danube Fairway Rehabilitation and Maintenance Master Plan" was developed by the Danube riparian states. It is a compilation of critical fairway maintenance sections and actions that need to be taken to resolve these bottlenecks. Its implementation is monitored by yearly Action Plans (see www.danube-navigation.eu).

Since 1962 similar activities were undertaken by the Moselle Commission and from 2005 onwards also by the International Sava River Basin Commission (ISRBC).

Regarding the **Moselle** river, the largest Rhine tributary, in 1956 the Moselle Convention was signed by Germany, France and Luxembourg with the goal to ensure the navigability of the river for vessels of up to 1,500 tons. According to the Convention, fairway parameters are set at 2.50 m fairway depth and at 40.00 m minimum fairway width.

The **Sava** river is the largest tributary of the Danube by discharge. In order to tackle the challenges on a river basin-wide scale, the Sava riparian states Slovenia, Croatia, Bosnia and Herzegovina and Serbia ratified a Framework Agreement on the Sava River Basin (FASRB) which entered into force in 2004. General provisions pursuant to navigation were set in a Protocol to the FASRB, while detailed parameters for waterway classification on the Sava river were published in 2009.

Multiple river commissions have been established on the river **Scheldt** to coordinate, manage, and maintain navigation on this international river. The 350 km long Scheldt has its source in France and then flows through Wallonia, Flanders and the Netherlands. Over 250 dams and locks connect river sections to each other and also link tributaries and canals. The International Scheldt Commission (ISC), the Flemish-Dutch Scheldt Commission (VNSC) and the Permanent Commission for Supervision of Scheldt Navigation (PC) ensure the implementation of international conventions and agreements on the river Scheldt. Each commission has a different focus, guaranteeing that all objectives are dealt with. The ISC coordinates integrated water management at the level of the entire river basin. The VNSC is working in the Scheldt estuary. Their aims are flood protection, accessible ports, and a healthy and dynamic estuary environment. The Permanent Commission ensures safe and effective shipping.

Flanders and the Netherlands have a coordinated, cross-border waterway maintenance and traffic management program. They agreed on various subjects such as flood protection, promotion and advancement of navigation and environmental protection. Both split the work of the necessary activities. For example, the Flemish Agency for Maritime Access conducts dredging works on Dutch territory. Both parties perform navigational traffic management; one half of the employees are from Flanders and the other from the Netherlands.

There are further commissions that have a cross-border or cross-corridor approach and focus on environmental protection, flood control and/or water policy, e.g. the International Commission for the Protection of the Danube River (ICPDR) and the International Commission for the Protection of the Rhine (ICPR).

6 Integrated management of multifunctional and multinational waterways

As waterways are usually multinational systems, cross-border cooperation and coordination is an absolute necessity for sustainable development. Such coordination – as performed by river commissions – has successfully proven to be a suitable tool to coordinate corridor-related developments and consequent actions (see, e.g., Good Practice Example A in Chapter 4.3). However, there still is a need to improve cooperation in the specific field of waterway maintenance on all European waterway corridors.

"System thinking" is the key to an integrated management of multifunctional and multinational waterways. This means that waterway corridors are considered as a system. Understanding how this specific system works or who plays which role in it supports a more effective and proactive waterway management strategy. Complex multinational waterway systems are characterized by a strong interaction between a large number of players and at times conflicting interests.

A systematic approach emphasizes a global, holistic view and acknowledges that an improvement in one area of the system can adversely affect another one. This approach focuses on problem solving by viewing "problems" as parts of an overall system rather than only reacting to specific parts, outcomes or events. This systematic process is of cyclical nature rather than based on linear cause and effect relationships. It promotes communication at all levels in order to avoid negative effects and creates synergies instead. To reach agreed goals, a continuous improvement process needs be applied and ongoing efforts have to be made.

Integrated waterway management is characterized by the following attributes:

Figure 7: System attributes of integrated waterway management

- *Targeted*: Every waterway maintenance or management activity should be performed with a defined target/defined targets, e.g. target value(s), level(s) of service, etc.
- *Strategic*: For a coordinated, effective and efficient achievement of targets, a specific waterway management strategy should be available.
- *Continuous*: Waterway management and maintenance is performed on a continuous, cyclical basis and should be regarded as a continual improvement process.
- *Multi-disciplinary*: Waterways are not only traffic routes but are characterized by a variety of other uses with at times conflicting interests.
- *Participatory*: Due to the multi-disciplinary character of waterways, participatory management is advisable in order to understand and respect the other uses of waterways.

6.1 Fairway maintenance strategy

The defined targets or target parameters for fairway maintenance have been specified in Chapter 5. The question of how to achieve these target parameters in the most effective and efficient way is essential for the performance of waterway authorities, especially in times of restricted resources (be it staff and/or equipment) and limited budgets. Hence, all related activities should be performed in accordance with a specific fairway maintenance or waterway management strategy which in itself should be designed as a continual improvement process. In this way, inefficiencies due to trial-and-error approaches lacking strategic orientation can be prevented.

For free-flowing sections of natural waterways, the determination of the currently available parameters of the fairway (i.e. its minimum depth and/or minimum width) is based on a "minimal" cross section. This minimal cross section is inferred from the "most shallow" and/or "most narrow" locations of a certain river section at low water levels. As far as cargo transport is concerned, it is mostly the available fairway depth which determines the possible maximum loaded draught of a vessel and hence the quantity of goods which can be transported on a specific route. Larger freight volumes per vessel or convoy also improve the relation between freight revenues and costs and thus the overall competitiveness of inland navigation. When loading vessels, ship operators often have to estimate available fairway depths at critical river stretches already days or weeks in advance before passing through them. This means that there is a direct relationship between fairway conditions, the load factor of vessels and freight revenues from specific vessel trips.

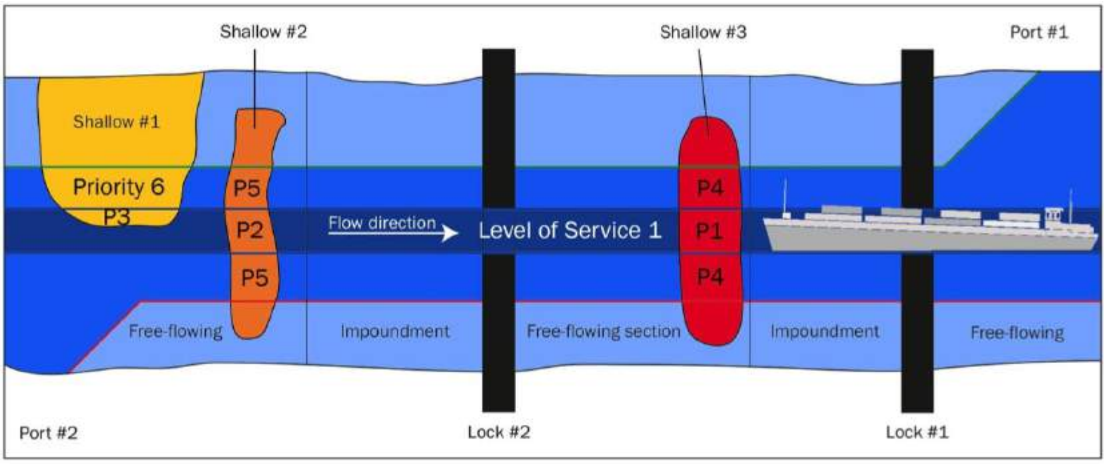
6.1.1 Continuity of the fairway

On longer transport routes – which are the majority of international inland waterway transport routes – bottlenecks arise especially in the form of short stretches of shallow or narrow sections. These determine the maximum possible loaded draught of vessels (and thus their maximum cargo load) on the entire route. In order to account for this correlation, the strategic principle of **providing the continuity of the fairway** should be applied in waterway maintenance activities. "Continuity of the fairway" here refers to the establishment of the continuous availability of minimum fairway parameters on a specific waterway section as a priority measure. A deep fairway channel shall be created in a proactive manner prior to low-water periods which usually appear annually during a certain time frame. (It shall be noted that low water periods in estuary rivers are influenced by the upstream discharge) .

Figure 8 provides a schematic overview of an inland waterway transport route. The dark blue ribbon in its centre represents the minimum width of the fairway. To achieve "Level of Service 1", the fairway shall always have a targeted minimum depth along the entire section of the waterway at a defined minimum water level for navigation (e.g. 2.5 m at Low Navigation Water Level on the Danube). To accomplish this, a priority order has to be set, starting with the most critical section (here: Shallow #3 marked in red). If the following critical sections are in a non-satisfactory condition, an additional increase of fairway width beyond the minimum width (i.e. the dark blue ribbon) would be a waste of budget as the effectiveness of this measure is limited depending on the condition of the next critical section. In such a case – as depicted by Figure 8 – it is necessary to ensure the target fairway depth along the minimal width first at Shallow #2 (priority 2 – P2), then at Shallow #1 (priority 3 – P3). Then continuous fairway parameters would be achieved for a minimum width of the fairway on an entire section of a waterway ("Level of Service 1").

In case of limited resources, not all necessary measures can be done in an optimal way. In order to continuously maintain fairway availability at a high level on an entire river stretch, a priority ranking

of different types of measures along that stretch (as described above) is required (see also Chapter 7.2 – Planning measures). The outcome of that ranking is dependent on the defined targets and the available resources.



Source: TU Wien, via donau, © Hayes

Figure 8: The principle of continuous fairway availability translated into prioritisation of proactive fairway maintenance intervention according to a defined minimum level of service (Level of Service 1); green line: left-hand boundary of the fairway; red line: right-hand boundary of the fairway

The continuity of the fairway has to be provided in regards to a targeted minimum fairway width. As described above, critical sections showing sedimentation on the entire width of the fairway, i.e. fords, shall be disintegrated in the first step (Shallow #2 and #3 in Figure 8). Critical sections characterized by lateral sedimentation (Shallow #1) only limit the continuity of the fairway to a certain extent but do not completely impede it. Hence, the latter should be given lower priority in providing the minimum level of service on a specific section of a waterway.

Once a minimum level of service (minimum width) is established in the fairway channel (see priority 1 to 3 in Figure 8), dredging within the entire – i.e. remaining – width of the fairway at critical locations (priority 4 to 6) should be performed during the rest of the low-water period. Then the fairway parameters as foreseen by international agreements and recommendations will be established.

However, establishing a sufficient target depth within the entire width of the fairway involves high maintenance costs on the part of the waterway authority. Calculations on the cost effectiveness of inland waterway transport (see NEWADA DUO 2014a) have clearly shown that a local limitation of fairway width, compared to a limitation of fairway depth, only shows minimal negative effects on transport costs, as a local narrowing of the fairway results in short waiting times for vessels in case of encounters. This additional time is marginal in relation to the average transport duration on an inland waterway. Thus the cost effectiveness of a continuous provision of recommended fairway width on river sections characterised by low transport volumes is questionable.

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6.1.2 Proactive fairway maintenance

After having a clear understanding on the priorities in regards to fairway continuity (see Chapter 6.1.1) the second principle of **proactive fairway maintenance** should be applied. It is of utmost importance for the timely provision of minimum fairway parameters.

Free-flowing stretches of (natural) rivers are characterised by frequently fluctuating water levels due to a strong direct dependence on weather conditions or tidal influences. Alpine rivers, for example, are characterised by a discharge regime which usually entails higher water levels during spring (snowmelt), summer and early fall, and lower water levels during late fall and winter months. Derived from this annual hydrological regime of the river, the optimum time frame for the start of priority maintenance works is prior to the beginning of the low-water period in early fall. The principle of establishing the continuous availability of minimum fairway parameters (2.5 m fairway depth at a limited fairway width) prior to the low-water period is user- and demand-oriented as it enables the navigation sector to benefit from higher cargo loads in that period and thus increases the economic efficiency of waterborne transport.

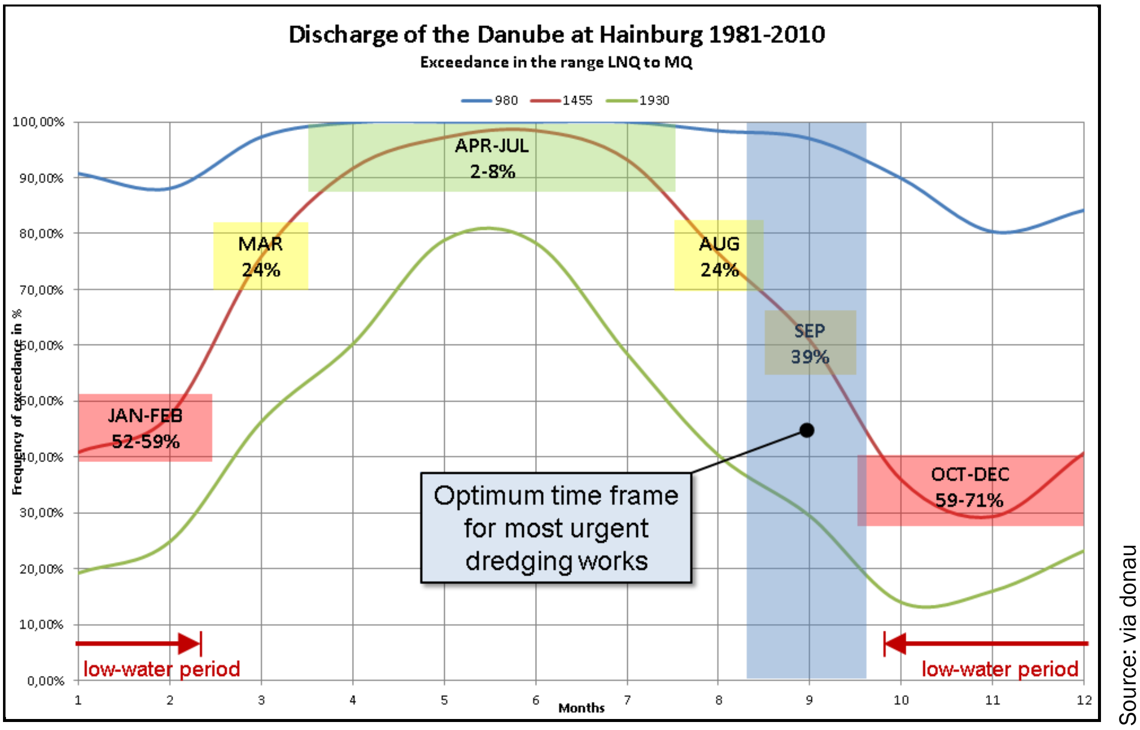

Figure 9: Frequency of exceedance of characteristic amounts of discharge at the Hainburg water gauge on the Austrian stretch of the Danube in the years 1981 through 2010 and inferred optimum time frame for most urgent dredging works

As an example, Figure 9 displays characteristic discharge curves at the Hainburg gauging station on the Upper Danube in Austria over a period of 30 years (1981–2010). This station represents a reference gauge for the free-flowing section of the Danube east of Vienna. On the Y-axis, the frequency of exceedance of discharge values is displayed in per cent, while the X-axis features the twelve months of a year. The discharge range in Figure 9 is between LNRQ (low navigation and regulation discharge) and MQ (mean discharge) (blue, red, and green lines).

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With regard to low navigation and regulation discharge (LNRQ, blue line), it is evident from the figure that this reference discharge was exceeded on almost 100% of days during the months of April through July. This means there were no low-water periods in these four months during the referenced 30 years. The months of March, August and September are also favourable for navigation, as they exceed the LNRQ on more than 95% of days. January and October are characterised by an exceedance of LNRQ of approximately 90%. The most critical months for navigation in terms of discharge volumes are January, February, November and December, as these show LNRQ exceedance between 90% and 80%. The month of November is characterised by the lowest discharge volumes. With regard to the 30-year period this means that on average the LNRQ is not reached on six days in the month of November on the Austrian stretch of the Danube.

Whether navigational bottlenecks can be removed in time according to the principle of proactive fairway maintenance depends on a number of budgetary, logistic, environmental and legal restrictions. Depending on each European country with inland waterways, a different importance and weight is given to these restrictions.

6.2 Continual improvement process

Derived from the two main strategic guiding principles of sustainable fairway maintenance, i.e. "providing the continuity of the fairway" and "proactive fairway maintenance", different levels of service in fairway maintenance may be defined. As a basis for all improvement processes, a **minimum or base level of service** needs to be identified. Then every quality improvement can be measured by means of performance indicators. In addition, the identification, monitoring and improvement of fairway-related service levels should be considered as a continuous improvement process (CIP) in waterway maintenance.

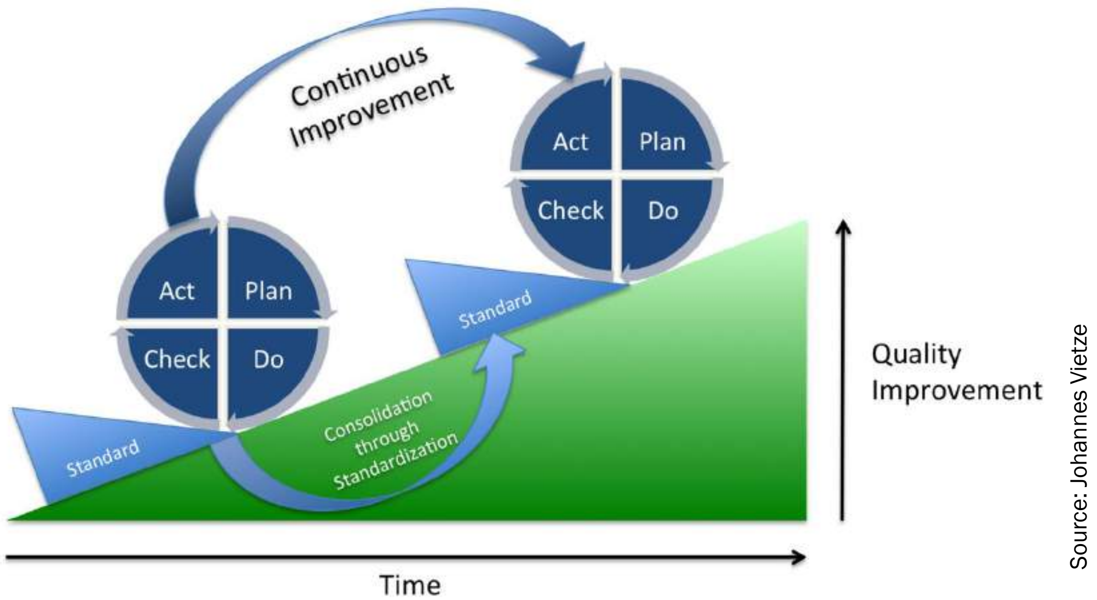

Figure 10: Continuous quality improvement with PDCA (plan-do-check-act)

In this context, the well-known quality management method PDCA (plan–do–check–act) can be adapted for the needs of modern waterway management and, subsequently, fairway maintenance (see Figure 10). The PDCA method consists of the four quality management steps "plan–do–check–act" which are continuously iterated in order to control and improve the quality of processes and products. Once a certain quality level is attained it has to be consolidated through standardization to counter the loss of gained experience or knowledge. Ideally, the continuous iteration of the four PDCA steps will yield a higher quality level, which again will be ensured by adapted standards, thus consolidating a new quality level of processes and products.

Iteration is a fundamental principle of both waterway maintenance and PDCA. Executing the cycle again will extend knowledge about the related activities on the operational level. Repeating the PDCA cycle on the basis of specific standards will support the achievement of objectives, usually an optimisation of operation and output.

Pertaining to waterway management and fairway maintenance, the consolidation of achievements by means of standardization can be performed by defining a base level of service. For this purpose, the concept of "**level of service**" can be described as a batch of qualitative measures that characterize the current operational conditions in waterway maintenance. The current operational conditions have a specific quality, which may range from poor to excellent. A base level of service defines the minimum requirements for operational conditions with regard to the management of a certain waterway stretch. From a corridor-oriented perspective, a *common* base level of service should be defined for harmonised waterway management on a multinational waterway.

6.2.1 Performance indicators

Compliance with and achievement of a certain (base) level of service can be measured by means of **performance indicators**, which are tools for strategic, tactical and operational planning and control. Performance indicators facilitate the evaluation of the success of a particular activity by periodic and comparable measurement and reporting and subsequently help to improve activities and results.

As a blueprint for waterway maintenance related performance indicators, the work achieved in this field by PIANC, the World Association for Waterborne Transport Infrastructure, and specifically their Report No. 111-2010 on "Performance Indicators for Inland Waterways Transport" can be used (PIANC 2010). Concerning the practical use of performance indicators, PIANC has listed the following characteristics (see PIANC 2010: 6):

- Performance indicators have a positive impact on the quality of specific actions and processes of an organization.
- Performance indicators can be the result or product of several performance measures and therefore also have an impact on these measures.
- Performance indicators are tied to an organization’s objective.
- Performance indicators are measured regularly.
- Responsibility for performance indicators can be attributed to teams or individuals.
- Performance indicators can be quantitative as well as qualitative measures.

- Responsible employees understand them and the corrective action they indicate.

The performance indicators recommended in the PIANC Guideline are aggregated into nine areas of application: (1) infrastructure, (2) ports, (3) environment, (4) fleet and vehicles, (5) cargo and passengers, (6) information and communication, (7) economic development, (8) safety, and (9) security (PIANC 2010: 6). PIANC also developed a standardised structure for the definition of performance indicators (see Figure 11).

Area of application ID	Name of the Area of Application	
Performance indicator ID	**Name of the performance indicator**	
Description	*Detailed description of the provided information*	
Calculation	*Formula that describes how to calculate the performance indicator*	
Basic Data	*Definition of basic data which are used within the formulas*	
Information	*Additional information that is necessary for deeper understanding*	
Measure	*Measurement unit in words*	
Collection	365	*Daily*
	52	*Weekly*
	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12	*Monthly*
	1 | 2 | 3 | 4	*Quarterly*
	1 | 2	*Semi-annually*
	1	*Annually*
Objective	*What is the objective that is followed by this performance indicator*	
Comment	*Further information or comment on the performance indicator*	
Complexity	*Indicates the level of implementation corresponding to the level of complexity of the recommended PI. It is therefore differentiated in three categories:* **Level 1** | **Level 2** | **Level 3**	
Application	*Indicates the recommended application of the PI within three categories:* **Operation** | **Information** | **Reference**	

Source: PIANC 2010

Figure 11: Standardised structure for performance indicators

Performance indicators for waterway management include points such as (NEWADA DUO 2014b):

- Minimum fairway depth and width in days per year (= availability of minimum fairway parameters),
- Disruption of navigation due to high water, low water, ice, wind, etc. in days per year (= availability of waterway infrastructure),
- Availability of lock chambers in days per year, average waiting time at locks in minutes (= availability of navigation locks),
- Measured parameters/frequency of critical section surveying in number of surveys per year (= surveying of the riverbed/measurement of flow discharge),
- Number of dredged sections per year, amount of dredged sediment in cubic meters (= dredging of critical sectors),
- Density and availability of buoys and marks, reaction time after damage caused by floods, ice, etc. in hours (= marking of the fairway).

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An example from the PIANC Guideline for a concrete application and formulae for calculating specific performance indicators for core waterway infrastructure availability is provided in Figure 12.

1	INFRASTRUCTURE	
1.3	**AVAILABILITY OF CORE WATERWAY INFRASTRUCTURE**	
Description	The main purpose of the following indicators is to present details about the availability of the core waterway itself. Therefore 3 sub-indicators are presented. They analyse the 3 factors, which have the **largest impact** on the general availability of the core waterway. • High water • Icing • Accidents These causes for stops of navigation on specific waterway sections are documented, summarised and completed by any other causes occurred to define the value '*total stop of navigation on a specific waterway section measured in days per year*' (see 'Terms' (1)). The availability of the core waterway is then compared to values of previous years.	
Calculation		
1.3. Availability of core waterway infrastructure $\frac{365 - Tot.stop / days\ per\ yr.}{Tot.nav.days\ /\ yr.}$ **1.3.1 Stop of navigation due to high water** $\frac{Stop\ high\ water / days\ yr}{Tot.nav.days / yr.}$ **1.3.2 Stop of navigation due to icing** $\frac{Stop\ icing / days\ yr}{Tot.nav.days / yr.}$ **1.3.3 Stop of navigation due to accidents** $\frac{Stop\ accidents / days\ yr}{Tot.nav.days / yr.}$ **1.3.4 Navigable days below waterway design value** $\frac{Nav.days\ below\ design\ draught / yr.}{Tot.nav.days / yr.}$		
Basic Data	**(1)** *Tot. stop/days per yr.*: total stop of navigation on a specific waterway section measured in days per year **(2)** *Stop high water /days yr.*: stop of navigation on a specific waterway section due to high water measured in days per year **(3)** *Stop icing/days yr.*: stop of navigation on a specific waterway section due to icing measured in days per year **(4)** *Stop accidents/days yr.*: stop of navigation on a specific waterway section due to accidents measured in days per year **(5)** *Nav. Days below design draught/yr.*: navigable days below design draught per year **(6)** *Tot.nav.days/yr.*: total navigable days per year	
Information	Since the different causes for stops of navigation along the inland waterways are analysed individually, the share of total stops can be detected and strategic plans for actions can be made to **reduce impacts** of the causes mentioned. By comparing availability of core waterway infrastructure to previous years **significant changes** over time can be recognised and strategies for improving competitiveness of inland navigation can be made (i.e. contracts for months with low water levels to shift transport volumes if necessary at short notice). The value navigable days below design draught per year is of significant importance for the entire inland navigation system, as proper nautical conditions enable cargo and passenger transport along waterways. If these conditions are not sufficient, cargo capacity is constricted and transport prices are affected.	
Measure	⇨ days/year ⇨ % Percent ⇨ % Change over time	
Collection	52	Weekly
Objective	↑ ☼ **Increase the percentage of the total availability of core waterway infrastructure on waterway section 'X' within time period 'Y' to a value of 'Z'.**	
Comment		

Source: PIANC 2010

Figure 12: Performance indicators for the availability of core waterway infrastructure

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Performance indicators must be related to a specific and predefined "target value", e.g. a specific level of service in waterway management. Quality management itself not only measures performance itself, but also compares it to certain quality levels (level of service) in order to trace the achievement of predefined targets and to trigger optimisation processes. Figure 13 provides a schematic overview on the interdependency of performance indicators and different levels of service. It shows that one and the same performance indicator may be used to measure the achievement of different targets or levels of service.

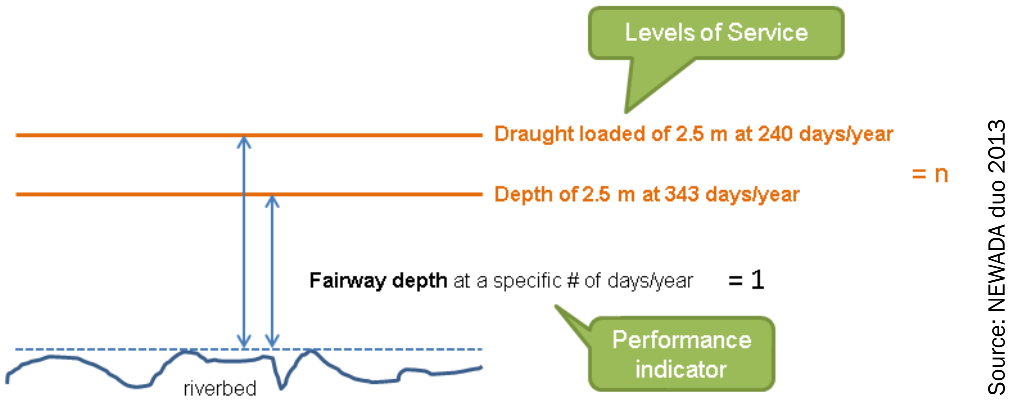

Figure 13: Interdependency of performance indicators and levels of service using the example of minimum fairway parameters

With the iterative use of performance indicators, a sustainable compliance with a certain "target value" or "level of service" can be achieved, avoiding a deficit or a surplus in performance (see Figure 14). In order to attain the optimum efficiency and effectiveness of an action, both a deficit and/or a surplus of performance should be avoided. On the basis of a specific set series of performance indications positive and negative deviations in target achievement are clearly visible.

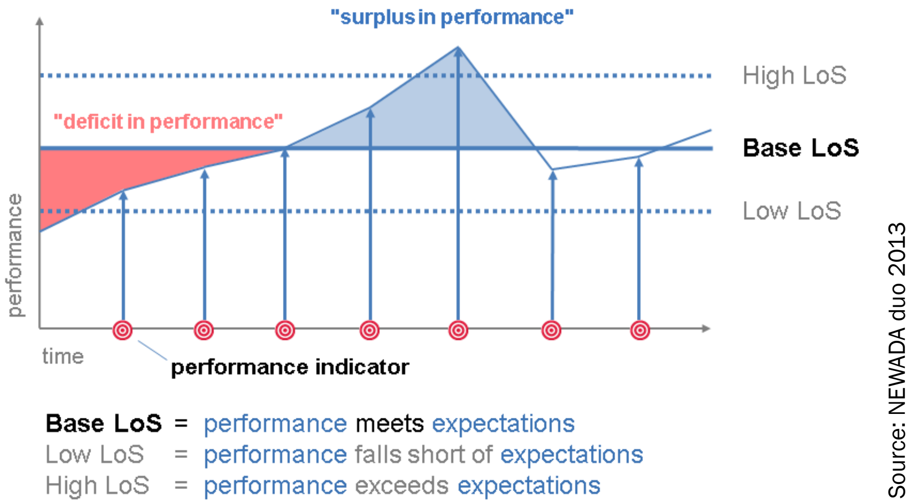

Figure 14: Steering of sustainable performance with the help of performance indicators

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6.2.2 Levels of service for fairway maintenance

For fairway maintenance and management, the main objective of **base level of service management** is to align the requirements of the users of the waterway with the quality of the services provided by the competent waterway authorities. This should be done:

- With a specific aim (target value, base level of service),
- In measurable terms (performance indicators), and
- In a sustainable way (monitoring, compliance with target value).

The most important requirements of inland navigation users with regard to waterway management are a competitive waterway infrastructure, up-to-date information on the status of the fairway and customer-orientation of services/authorities.

The Serbian Directorate for Inland Waterways (Plovput) established a programme that is based on the above stated objective and the listed parameters. Through the establishment of levels of service, calculations were performed that successfully helped prioritize measures for fairway maintenance.

B) ESTABLISHING FAIRWAY PARAMETERS ON THE BASIS OF LEVELS OF SERVICE	Danube Serbia
Problem/topic	
Definition and implementation of the Level of Service principle related to fairway parameters on Serbian national waterways.	
Objectives	
The over-arching goal of the management strategy described below is to ensure planning of proper technical maintenance measures in order to guarantee the continuity of the fairway during low water periods, unlike large-scale river training works, which aim at creating a new potential of waterways. Specific goals are: • To establish a tool-based support of management decisions related to fairway interventions. • To ensure proper monitoring of critical sectors on free-flowing river sections. • To provide integrated information on fairway availability to waterway users. • To ensure proper use of a limited budget and resources for technical maintenance of the river Danube.	
Background information	
The Serbian waterway authority Plovput manages and maintains free-flowing, highly dynamic stretches of the Danube. They developed a basic concept of the inland waterway management and maintenance process that includes the following activities (see **Figure 15**): • Hydrographic survey and data acquisition (of hydrographical and hydrological data). • Database integration, monitoring and analysis: Data is stored in different databases and cross-linked and integrated into a single management tool which is being used for analysis	

B) ESTABLISHING FAIRWAY PARAMETERS ON THE BASIS OF LEVELS OF SERVICE	Danube Serbia

and monitoring of the navigation conditions.

- The same tool also assists in the planning of fairway maintenance interventions.
- It also provides information on navigability and current fairway conditions (fairway information provision).

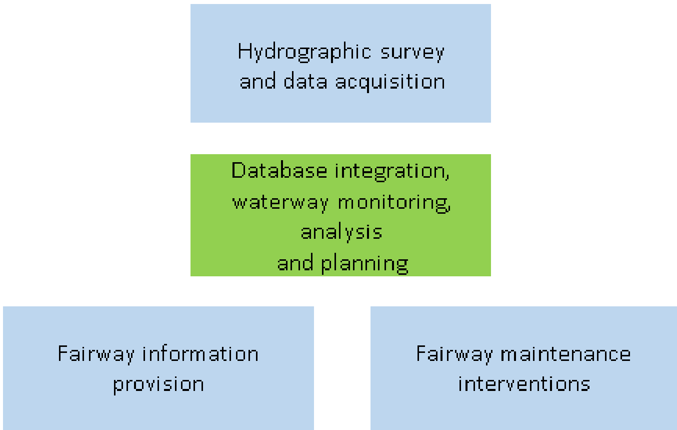

Figure 15: Basic concept of inland waterway management and maintenance

The central part of this process is database integration, waterway monitoring, analysis and planning. This part connects the other ones. The consistent interpretation of all collected data is enabled. As well as its input into a tool for management decisions related to fairway interventions (fairway realignment, proposal for traffic regulations, or dredging of the sediment), and for the parallel process of provision of integrated information on the availability of the fairway to its users.

Description of activities

To determine the available and targeted level of service in terms of fairway parameters, following data is used:

- Hydrographic survey data for the free-flowing stretch of the river,
- Characteristic water levels (LNRLs – low navigation and regulation levels/ENRs – étiages navigable et de régularisation) defined for each cross section (derived from the 1D hydraulic model), and
- Defined fairway parameters (depth and width of the fairway).

By integrating these data, the following purposes are achieved:

- Calculation of achieved level of service (available depth and width of the fairway) is performed,
- Critical sectors and non-critical sectors (in terms of navigation conditions) are monitored – to know how much work has to be done in the first and to confirm that no work is necessary in the latter,
- Targeted levels of service (targeted depth and width of the fairway) are defined,

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B) ESTABLISHING FAIRWAY PARAMETERS ON THE BASIS OF LEVELS OF SERVICE

Danube

Serbia

- Critical sections for technical maintenance activities (sediment dredging) are prioritized,
- The quantity of sediment to be dredged in order to achieve targeted level of service is calculated.

The free-flowing Danube stretch bordering Croatia and Serbia is analyzed annually. According to the 2013 results, 17 critical sectors for navigation were identified on this stretch. These are river sectors where the required fairway dimensions (depth and width) for safe navigation are not fulfilled during low water periods. Depth was not changed for the purpose of this analysis, and it is predefined at 2.5 m below ENR. Fairway width is an adjustable variable, related to current and forecasted traffic density, referenced structure of convoys, as well as to available budget for fairway interventions.

Prioritization of critical sectors for technical maintenance by dredging of sediment is related to the available fairway width (with 2.5 m depth below ENR). Depending on the available budget for dredging measures (in terms of quantity of sediment) following options would be implemented (in this order):

- Option 1: Dredging of 12,000 m3 at the critical sector Staklar (in total 12,000 m3),
- Option 2: Dredging of 35,000 m3 at the critical sector Staklar and 12,000 m3 at Borovo I (in total 47,000 m3); and
- Option 3: Dredging of 71,000 m3 at the critical sector Staklar, 24,000 m3 at Borovo I, and 12,000 m3 at Vukovar (in total 107,000 m3).

If critical sectors would be analyzed in terms of the quantity of sediment to be dredged in order to achieve the full recommended width of the fairway, then critical sector Vukovar would be ranked at the fifth place, while in this approach the Vukovar sector is ranked third. The basic idea for such a concept is to ensure that the budget for the technical maintenance by the means of dredging is spent at the most critical locations, in order to preserve the continuity of navigation – even at a reduced fairway width.

Figure 16 visualizes the quantities of sediment that have to be dredged in order to achieve different levels of service in terms of available fairway parameters. It can be seen that less than 100,000 m^3 have to be dredged in order to achieve fairway a width of 100 m, while achieving the full width of 200 m at all critical sectors would require dredging of 600,000 m^3.

Following these calculations, most critical sectors were further analyzed using hydrological data (water levels from referenced gauging stations). This step aims at verifying the methodology. The number of days in 2013 during which a depth of 2.5 m was (not) available was calculated.

This calculation confirmed that the sector Staklar was the most critical in 2013. There the fairway width of 100 m (with 2.5 m depth) was not achieved on 54 days. During the year 2013 water levels did not drop below ENR. Still, this which means that this sector is critical and that narrowing of the fairway's width is necessary even before the water levels drop to the level of ENR.

Similar analyses were performed for other critical sectors, confirming the consistency of the methodology.

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B) ESTABLISHING FAIRWAY PARAMETERS ON THE BASIS OF LEVELS OF SERVICE	Danube
	Serbia

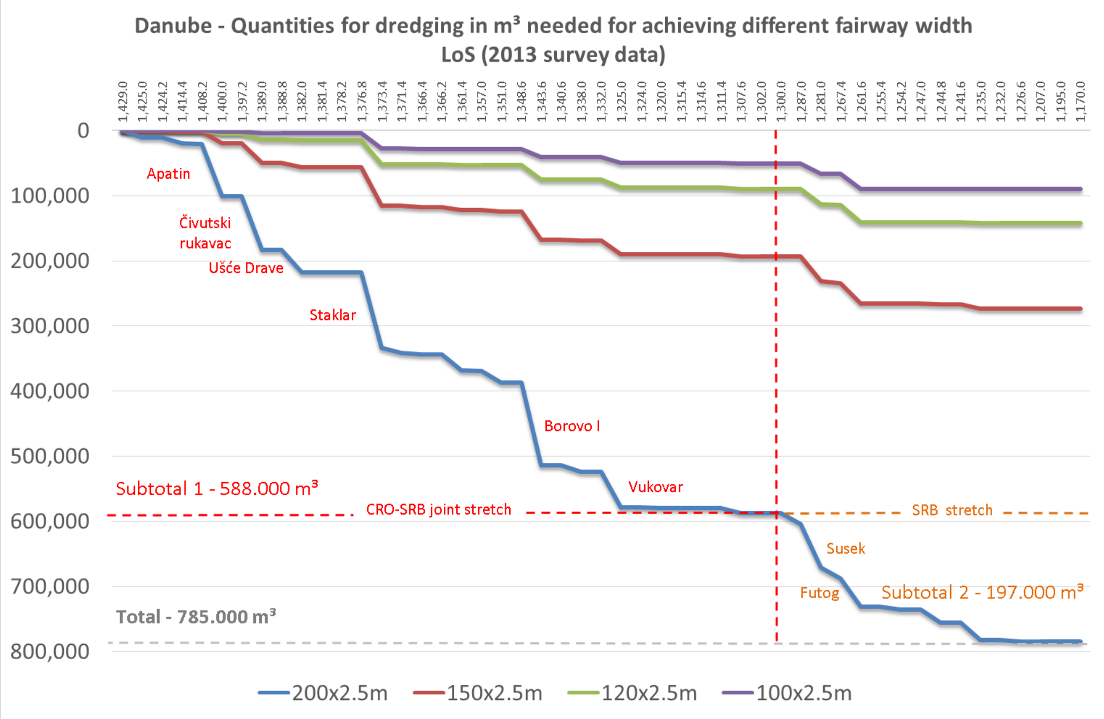

Figure 16: Quantities for dredging needed for achieving different LoS for fairway width

Users and stakeholders

- Navigation, shipping and logistics companies as users of the waterway.
- Navigation authorities as responsible actors for traffic safety.
- The national waterway administrations Plovput (Serbia) and SVP (Croatia) are the responsible waterway infrastructure operators.
- Environmental stakeholders, as they profit from improved measures

Key success factors and innovative aspects

The main prerequisite and success factor for the portrayed management strategy is database integration of information on the current state of the fairway (hydrographical and hydrological data). The calculation of possible measures on the basis of defined levels of service (fairway width and depth) in combination with a prioritization of measures which is effect-driven, i.e. determining which measure will have the highest impact on fairway availability at the lowest costs (effectivity and efficiency), can be characterized as an innovative aspect.

Time frame and status

This methodology has been applied as of 2013. With every new survey, new calculations are being made.

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B) ESTABLISHING FAIRWAY PARAMETERS ON THE BASIS OF LEVELS OF SERVICE	Danube Serbia
Lessons learned	
The methodology has proven essential in the decision making process and planning of maintenance activities. It enables identifying the measures with the best effects on fairway availability against the background of Ivery restricted financial capabilities.	
Requirements for implementation in other Member States	
To conduct such calculations, a sufficient number and quality of hydrographic riverbed surveys has to be performed during the year. Data regarding water levels at reference water gauges has to be available and comparable. This hydrographical and hydrological data is integrated into databases. Targeted levels of service (targeted fairway width/depth) for specific waterways and/or stretches have to be defined.	
Further information/contact	
Mr. Ivan Mitrovic Project Manager Directorate for Inland Waterways – Plovput Francuska 9, 11000 Belgrade, Republic of Serbia www.plovput.rs	

Another Good Practice Example on the Danube river is the following trans-national approach. It was established during the EU co-funded project NEWADA duo and aimed at defining common minimum levels of service for waterway management in the Danube corridor. For each level of service performance indicators were defined. These are published in the annual "Danube Report".

C) COMMON MINIMUM LEVEL OF SERVICE FOR WATERWAY MANAGEMENT ON THE DANUBE	Danube Danube Corridor
Problem/topic	
The Danube is an international waterway. Each of the ten riparian countries is responsible for waterway maintenance on their respective river section. International recommendations for fairway parameters (with, depth, vertical clearance) do exist, but cannot always be met due to strongly fluctuating water levels and deficiencies regarding equipment, staff and budget of the respective national waterway operator. With regard to this background, the definition of a common minimum level of service (LoS) for fairway maintenance and waterway management would help to at least provide waterway users with a continuous fairway on the Danube together with harmonized and up-to-date information on the current sate of waterway infrastructure.	
Objectives	
• To define common trans-national minimum levels of service for fairway maintenance and waterway management for the Danube waterway from Austria to Romania (i.e. in the seven	

C) COMMON MINIMUM LEVEL OF SERVICE FOR WATERWAY MANAGEMENT ON THE DANUBE	Danube Danube Corridor

Danube riparian states which were partners in the NEWADA duo project[9]).

- To define corresponding performance indicators in order to monitor the provision of the set common minimum LoS by waterway operators.
- To visualize the performance indicators in a user-friendly way and make them accessible to the public.

Background information

In the past, Danube waterway administrations had only partly used performance indicators to measure a specific level of service on a national basis. Internationally harmonized performance indicators for waterway infrastructure did not exist.

Both the common minimum level of service as well as the related set of performance indicators do neither apply to the German stretch of the Danube waterway (as the German waterway management authority was not a NEWADA duo project partner), nor to the lower reaches of the Danube which are defined as a maritime waterway (river km 0 to 175) and for which different recommendations as to fairway parameters have to be applied.

Description of activities

During the EU co-funded NEWADA duo project, the Danube waterway administrations discussed and identified common performance indicators and a minimum LoS for waterway transport on the Danube with a strong focus on waterway infrastructure. This was based on PIANC (2010).

Nine different level of service areas ("LoS areas"), as well as a common minimum level of service (LoS) for each area were identified. The areas were clustered into three main topics:

Main topic	*LoS area*
Core waterway infrastructure	• Minimum fairway parameters (depth and width) • Availability of locks/lock chambers
Core waterway maintenance activities	• Surveying of the riverbed (bathymetry) • Marking of the fairway (floating and land-based signs and marks) • Water level gauges
Fairway-related information to users	• Water levels and forecasts • Available fairway depths • Marking of the fairway (marking plans) • Meteorological information

For each LoS area key performance indicators were defined (incl. formulae for calculating these

[9] Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania.

C) COMMON MINIMUM LEVEL OF SERVICE FOR WATERWAY MANAGEMENT ON THE DANUBE	Danube Danube Corridor

indicators), as well as concrete examples for their visualization and publication. The user-friendly visualization of performance indicators is one important objective, as they are published in the common "Danube Report" which is drafted annually by the NEWADA partnership.

Users and stakeholders

- Navigation, shipping and logistics companies as users of the waterway.
- Danube waterway administrations as the responsible waterway infrastructure operators.
- Navigation authorities as responsible actors for traffic safety.

Key success factors and innovative aspects

- Crucial prerequisite for the definition and compliance with a certain minimum LoS is the availability and quality of basic data needed to calculate corresponding performance indicators.
- Compliance with a minimum LoS needs to be monitored on a continuous scale, e.g. with the help of dedicated performance indicators.
- An innovative aspect is the definition and monitoring of a trans-national basic LoS for an entire transport corridor.

Time frame and status

Both the common minimum LoS in Danube waterway maintenance and management as well as the related performance indicators were endorsed by the managing directors of the waterway administrations during the fifth Board of Directors meeting in Zagreb on 5 and 6 November 2014 during the NEWADA duo project.

In addition, the technical, budgetary (investment and operational costs) and staff needs regarding future fairway maintenance and management activities on the Danube were identified on the basis of the defined minimum common LoS. They addressed discrepancies between the quality of current fairway maintenance and management as well as the desired conditions according to the defined minimum LoS. A consolidated report on these findings was published in May 2014.

Based on the findings of this "gap analysis", a "Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries" was developed within the framework of the EU Strategy for the Danube Region (EUSDR) (see EU STRATEGY FOR THE DANUBE REGION 2014). It comprises a list of critical sections aliong the Danube and an analysis of the required actions and resulting cost. The Master Plan was endorsed by the Danube Ministers of Transport on 3 December 2014. Its implementation is coordinated via National Action Plans (www.danube-navigation.eu).

Scores on key performance indicators are published annually in the "Danube Report" which is drafted by the members of the NEWADA partnership.

Lessons learned

- For international waterways with several riparian countries in charge of fairway maintenance,

<table>
<tr><th>C) COMMON MINIMUM LEVEL OF SERVICE FOR WATERWAY MANAGEMENT ON THE DANUBE</th><th>Danube
Danube Corridor</th></tr>
<tr><td colspan="2">the definition of a trans-national level of service for waterway maintenance is crucial in order to provide the waterway users a continuous infrastructure quality.
• Levels of service are not static and should thus also be made part of a continuous improvement process; corresponding performance indicators should also be updated on a regular basis.</td></tr>
<tr><td colspan="2">Requirements for implementation in other Member States</td></tr>
<tr><td colspan="2">A prerequisite for such processes are meetings where waterway authorities or administrations can talk about the operational level. Once the participating Member States agree on the definition of the minimum LoS it is of equal importance that the politically responsible units endorse this agreement too and provide the necessary framework for implementation (sufficient staff, equipment, budget).</td></tr>
<tr><td colspan="2">Further information/contact</td></tr>
<tr><td colspan="2">Mr. Thomas Hartl
via donau – Österreichische Wasserstraßen-Gesellschaft mbH
Donau-City-Straße 1, 1220 Vienna
thomas.hartl@viadonau.org
+43 50 4321 1603</td></tr>
</table>

Key Performance Indicators for waterways are also a subject of the TEN-T corridor studies which are currently being updated. Further studies on the "Good Navigation Status" of waterways and infrastructure data are expected to be assigned by the European Commission. Further information on the corridor studies is available on http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/corridors/corridor-studies_en.htm.

6.3 Multi-disciplinary approach

In addition to commercial cargo and passenger navigation, a number of other uses are provided by a natural waterway (see Figure 17). Uses related to tourism and recreation (e.g. leisure crafting or fishing), water management (flood protection, disposal of waste water, agricultural irrigation), landscape and ecosystem as well as hydroelectricity (energy production through hydropower plants) pose additional requirements that need to be satisfied. Therefore, managing – and thus also maintaining – a waterway means to take economic, ecological, social and political requirements into account and to pay respect to the views and needs of relevant stakeholders.

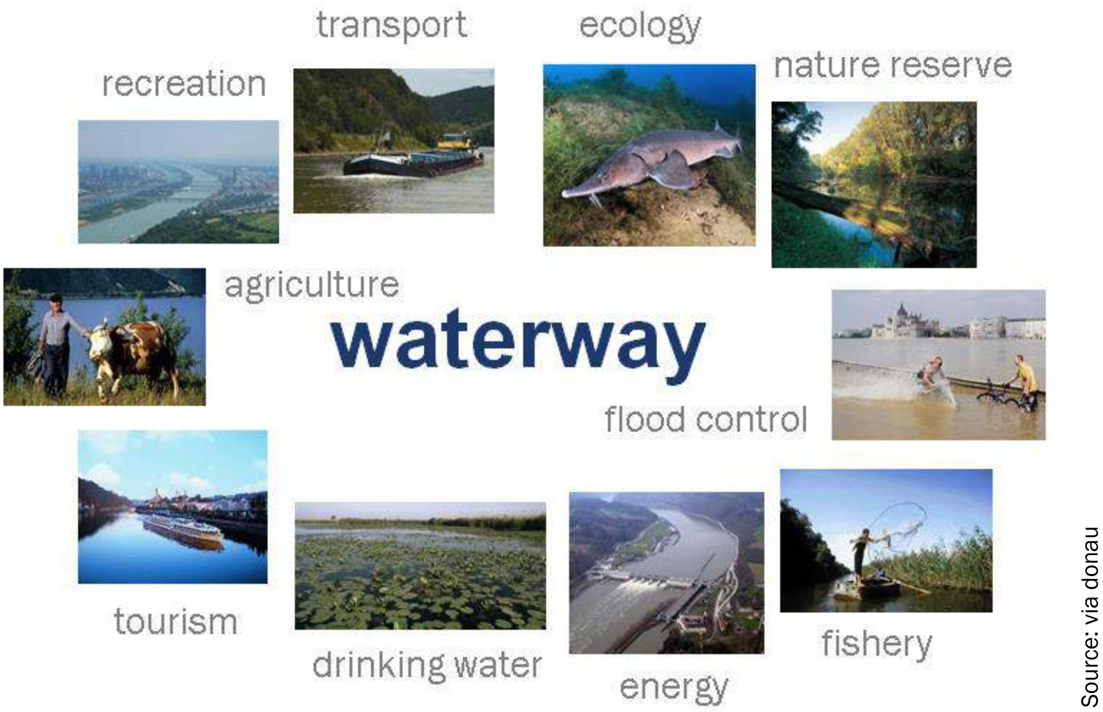

Figure 17: Multi-disciplinary use of waterways

As these uses are not confined by a single site, but are influenced by the whole catchment area, there exists a significant need for cross-border and corridor-oriented coordination between activities of riparian countries, especially concerning maintenance of common border stretches of waterways.

Due to these aspects waterway management is an important part of **integrated river basin management** which might be defined as "the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems" (WORLD WIDE FUND FOR NATURE 2015[10]).

[10] Adapted from Integrated Water Resources Management, Global Water Partnership Technical Advisory Committee Background Papers No. 4/2000.

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6.3.1 Fairway maintenance and environmental protection

Environmental needs must be considered in waterway maintenance works. The existing legal framework caters for the safeguarding of environmental objectives in parallel to navigation-related ones. The corresponding regulations must be applied in the planning as well as the implementation phase of waterway related measures and affect maintenance activities in a tangible spatial and temporal way.

Based on the fact that safeguarding environmental aspects is a key precondition of waterway maintenance works and it is secured by the existing legal framework, this manual refrains from providing very detailed environment-related recommendations for specific measures. This manual is a basic document and thus provides general guidelines. The concrete design of measures is strongly dependant on site-specific preconditions and thus on a high level of detail. Furthermore, each maintenance measure needs to be based on legal permits considering EU, national and local law. This framework makes sure that the respective needs related to water, environment etc. are taken into account. This manual does not evaluate the national interpretations of environmental legislation.

The impact environmental regulations have on physical interventions depends on whether or not a waterway maintenance action has an intensive impact on the respective water body or ecosystem. The significance of adverse environmental effects depends on site-specific factors that govern the vulnerability and sensitivity of environmental resources in the project area such as discharge regime, hydro-morphological conditions, habitats and species.

To counteract negative impacts and to ensure ecosystem stability, the European Commission set legislative instruments. The most considerable **EU legislative instruments** are the **Water Framework Directive** (2000/60/EC), the **Environmental Impact Assessment Directive** (85/337/EEC) and the **Habitats Directive** (92/43/EEC) in connection with the **Birds Directive** (2009/147/EC). Other Directives that have to be mentioned are the Strategic Environmental Assessment Directive (2001/42/EC) and the Public Participation Directive (2003/35/EC). These Directives cover the aspects of managing natural resources, protected species and protected sites in or close to project areas whereas public participation and strategic environmental assessment additionally integrate the aspect of public[11] consultation. These are the basis for revisions of national law. Permission procedures concerning these aspects during maintenance or development activities often require comprising contemplation during the project planning phase and thorough examination/monitoring during and after the implementation phase. Further information about integrated planning with a focus on the implementation of structural river engineering works can be acquired in the downloadable "Manual on Good Practices in Sustainable Waterway Planning" from the PLATINA project (ICPDR 2010).

The EU Birds Directive and the EU Habitats Directive form the central element of the Union's environmental policy: the **Natura 2000 Network**. Until December 2013, 27,308 sites with a spatial extent of approximately 1.04 million km² in the 28 EU Member States have been declared as protected (EUROPEAN COMMISSION 2015b). Figure 18 shows their abundance/expansion on a European scale.

Natura 2000 sites are not excluded from further infrastructural development. Instead their status implies thorough assessment that safeguards the existing genetics, species and ecosystem diversity.

11 The term "public" refers to the definition as laid down in Article 2 (d) of Directive 2001/42/EC.

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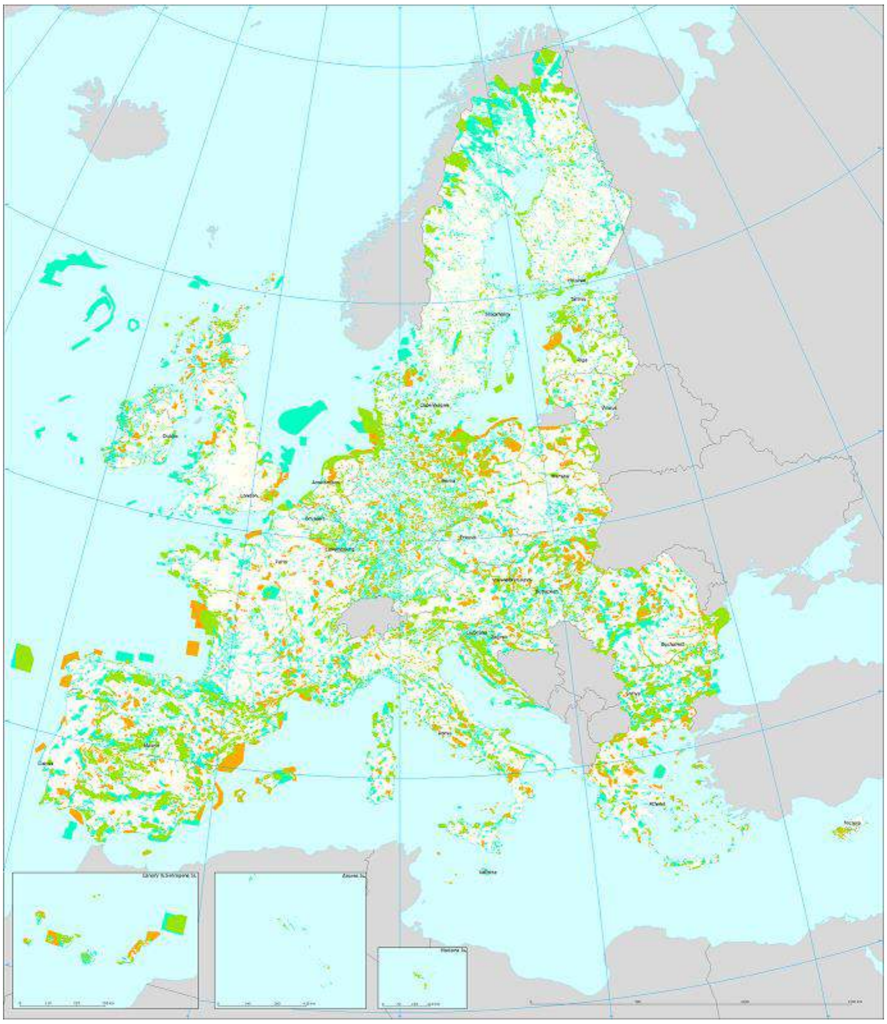
Waterways are often enclosed or flanked by protected areas, eventually because surface water bodies and their terrestrial surroundings (like riparian forests, marches, tidal flats, wetlands, etc.) accommodate a vast floral and faunal diversity. Henceforth water-related infrastructural development and maintenance activities have to be coordinated with environmental administrations (e.g. temporal and spatial restrictions for dredging). In 2012, the European Commission's Directorate-General for Environment thus issued a **Guidance Document on Inland Waterway Transport and Natura 2000** (EUROPEAN COMMISSION 2012b) in which a sound description of navigation's (including development and maintenance activities) environmental policy. It also stresses the importance of integrated planning in respect to environmental engineering and river restoration.



Source: European Environment Agency

Figure 18: The protected sites of the EU Natura 2000 Network

In general, all water bodies are covered by the requirements of the **Water Framework Directive**, even if they lie in areas outside of nature conservation areas. This is particularly important regarding the principle of preventing deterioration and regarding the achievement of the Water Framework Directive (WFD) objectives.The WFD requires Member States in Article 4.1(a) (i) to "implement the necessary measures to prevent deterioration of the status of all bodies of surface water" (European Commission 2000). Another goal is to protect, enhance, (and restore) these water bodies in order to attain the (i) good surface water status, or (ii) good ecological potential and good surface water chemical status.

The WFD had to be transposed into in national law by the end of 2003. By 2009, first river basin management plans had to be set up including a broad assessment of the current situation of the river basin regarding several criteria. Furthermore, they need to comprise a programme of measures, The plans illustrate an outlook on ongoing and planned projects affecting the river and their influence on achivieving the target of good surface water status or good ecological potential (for heavily modified water bodies) by the end of 2015. Updates of the plans take place every 6 years. Key Future Infrastucture Projects (FIP) regarding navigation are listed and assessed regarding their compliance with the WFD objectives, mainly regarding their influence on the status of the water way, which is defined by several quality elements (for further information on this topic see page 92) .

As with NATURA 2000, the national (and sometimes regional) authorities act in the framework of the national water laws, which are in turn the national implementation mechanisms of the WFD when it comes to environmental permits for fairway rehabilitation and maintenance activities. These authorities also organise official expert opinions and stakeholder management; all directly involved stakeholders are treated as a party in these national proceedings.

Another important document was issued by PIANC, The World Association for Waterborne Transport Infrastructure, in 2008: The Position Paper **Working with Nature** (PIANC 2008). It contains a strategic orientation of necessary inland waterway development and maintenance interventions towards an integrated planning approach. It strives to sensitize project promoters to consider sustainable solutions already at the beginning of the project planning phase. PIANC puts great effort in integrating environmental concerns into the maintenance and development of waterways, may they be maritime or inland waterways. The technical reports of PIANC's Environmental Commission[12] comprise topics related to waterborne transport containing state-of-the-art equipment and operational standards for the implementation of water-related projects – referring from bird habitat management over dredging equipment to flood management.

In order to bring together the sometimes conflicting interests of navigation and the environment in the Danube region, the International Commission for the Protection of the Danube River (ICPDR), the Danube Commission (navigation), and the International Sava River Basin Commission (ISRBC) joined forces and endorsed a **Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection** in 2008 (see ICPDR 2008). The statement provides integrative guiding principles and criteria for the planning and implementation of waterway projects with a strong focus on future river engineering projects on the Danube and its navigable tributaries. It opts for an interdisciplinary planning approach and the establishment of a "common language" across all disciplines involved in the process. Recommendations included in the document pertain to an integrated planning approach for the Danube river basin, integrated planning principles, and criteria for river engineering.

12 Technical Reports of the Environmental Commission: http://www.pianc.org/technicalreportsbrowseall.php.

The recommendations of the Joint Statement are also applicable within the fairway maintenance cycle. However, as maintenance measures are comparably small and to be implemented on a long-term, regular basis, applying the fully-fledged process would not be in proportion. Like any measure affecting waterways, maintenance measures have to be enacted within the existing environmental framework. This includes that qualified external experts need to assess the planned (programme of) measures regarding their environmental impacts and, if needed, specify conditions and requirements to be taken into account during implementation. This procedure is regulated by the applicable legal framework.

In order to facilitate and ensure the application of the Joint Statement and to lift its principles to the European level, a **Manual on Good Practices in Sustainable Waterway Planning** was developed by the ICPDR and relevant stakeholders in the Danube region within the framework of the EU project PLATINA in 2010 (see ICPDR 2010). Like the Joint Statement, the Manual also mainly focuses on structural measures (river engineering project) for the development of inland waterways. The basic philosophy is the integration of environmental objectives into the project design, thus preventing legal environmental barriers and significantly reducing the amount of potential compensation measures. The Manual proposes the following essential features for integrated planning:

- Identification of integrated project objectives comprising inland navigation aims, environmental needs and the objectives of other uses of the river reach such as nature protection, flood management and fishery,
- Integration of relevant stakeholders in the initial scoping phase of a project,
- Implementation of an integrated planning process to translate environmental and inland navigation objectives into concrete project measures thereby creating win-win results, and
- Conduct of comprehensive environmental monitoring prior, during and after project works, thereby enabling an adaptive implementation of the project when necessary.

According to the PLATINA I Manual, the objectives of a navigation project (such as the achievement of certain fairway dimensions and ecological requirements) can generally be achieved through various non-structural measures (capital and maintenance dredging) and structural measures (groynes, guiding walls, chevrons, river bank restoration, side-arm reconnection etc.) in various forms (concrete, rocks, stones or fixed deadwood).

The recommendations as to fairway maintenance measures provided in the ICPDR/PLATINA Manual read as follows: "Modern dredging strategies should prohibit the extraction of material from the river for commercial reasons. In case of maintenance dredging for navigation (e.g. yearly ford dredging) a refilling of the material should be performed upstream."

The Manual at hand elaborates the above mentioned principle, as no *general* recommendation regarding the location of the reinserted material can be given. A case by case approach shall be applied respecting the following basic principles :

- Sediment dredged from a free flowing stretch should be put back into the same free flowing stretch of the river in order to preserve its sediment balance. The (if available) applicable sediment management plan might foresee not to reinsert the dredged sediment, which can be possible if it does not cause negative impacts on the sediment balance of the river stretch.[13]

- Whether reinserted sediment can or should be immobilized, e.g. by putting it back into groin fields, depends on the specific location and desired effects; it should be decided on case-by-case basis

The following criteria need to be considered when developing dredging measures:

- Analysis of applicable legal framework inclusing river basin management plans and resulting requirements and coordination potential
- Location of the dredging sites
- Locations of nearest upstream dam due to their significant influence on the sediment regime
- Definition of the stretch on which the sediment balance principle should be followed
- Type of sediment (plays an essential role, as frequency and backfilling rates are not the same for different sediment types, e.g. gravel and sand)
- Ecological needs, particularly concerning discharge and seasons (ICPDR 2010: 93).
- Type of sedimentation process (longitudinal or lateral)
- State of the water body regarding existing river training structures that influence the natural river flow
- State of river banks influencing erosion processes and, consequently, also sediment transport regime
- Availability of hydrodynamic and morphological models, especially calibrated to low water periods
- Precisely calculated back filling rates

Among the examples for (integrated) planning concepts for waterway development included in the ICPDR/PLATINA Manual is the decision support framework for maintenance dredging on the river Thames, which focuses on user information and user integration (see Chapter 7.5). Since 2001, a so-called "dredging liaison group", with diverse membership, has become an open forum to discuss ongoing and proposed maintenance and dredging operations on the tidal Thames. An electronic

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[13] Such a Plan (Sava River Basin Management Plan) is to be developed by the Sava River countries and adopted by the Sava Commission (see also ISRBC 2015). The plan will, among others, cover

- Sediment balance throughout the river system
- Evaluation of the sediment quantity and quality
- Measures to control erosion and sediment processes
- Designated areas for capital dredging
- Guidance for the sediment disposal, treatment and use

Dredging Spatial Information System (DSIS) eases decision-making and allows for information sharing, and a Conservation Management Framework (CMF) supports a similar process on nature conservation issues (see ICPDR 2010: 86).

A document which is decidedly aiming at the intersection of environmental protection and fairway maintenance (specifically dredging) is the report **Dredging Management Practices for the Environment** which was published by the Environmental Commission of the World Association for Waterborne Transport Infrastructure in 2009 (see PIANC 2009). PIANC here displays the full process of dredging projects from conception to execution. The focus of the Report lies on environmental management, i.e. the correct inclusion of environmental concerns (restrictions and requirements) into "management practices" with the goal to elaborate "best management practices". The report is mainly based on the activities of marine dredging but also contains useful thought-provoking impulses that can be adapted to inland dredging projects as well. The different aspects of environmentally sound dredging are discussed in detail in the following sections.

Risk assessment

Every dredging project holds site-specific environmental risks and planning uncertainties, which can be mitigated through integrated project planning, but will never be fully predictable or avoidable. If environmental risk assessment in an early planning phase (after conceptual design) proves that the environmental risks are such that they cannot be mitigated by implementation of the appropriate best management practice (BMP) or management practice (MP) the project should be reconsidered and functional requirements should be redefined. The above-mentioned report (PIANC 2009) gives an overview about possible process adaptions at the different project phases and includes a list of relevant stakeholders to report to due to risk management and risk communication. Risk perception varies between groups and individuals and is value driven. There is no quick solution to this potential conflict; early and open communication is considered essential (see Chapter 6.3.2).

Dredging equipment

As mentioned before, PIANC 2009 mainly focuses on marine sediment dredging activities. The dredged material consists of silt and sand, but can also be rock or gravel. However, there are similarities in marine and inland dredging that allow a comprising view of the available technologies.

The main types of dredgers used throughout the world are hydraulic dredgers and mechanical dredgers. The differences between these two types are the way that sediments are excavated, either hydraulic or mechanical (VLASBLOM 2003: 2). Each type of dredger has its own advantages in terms of economic use and environmental effects under the specific conditions.

As to hydraulic dredgers, trailing suction hopper dredgers (TSHDs) are used for maintenance or capital dredging of unconsolidated sediments of lower to medium strength (i.e. silt or sand), while cutter suction dredgers (CSDs) are most commonly used for removing hard sediments in capital dredging projects (e.g. rock). Mechanical dredgers can be used in many types of projects and for a wide range of soils (e.g. backhoe dredgers and bucket ladder dredgers for gravel), but generally have much lower rates of production than hydraulic dredgers. With the exception of the trailing suction hopper dredger, all dredgers are stationary dredgers, which means that they are anchored by wires or spud poles.

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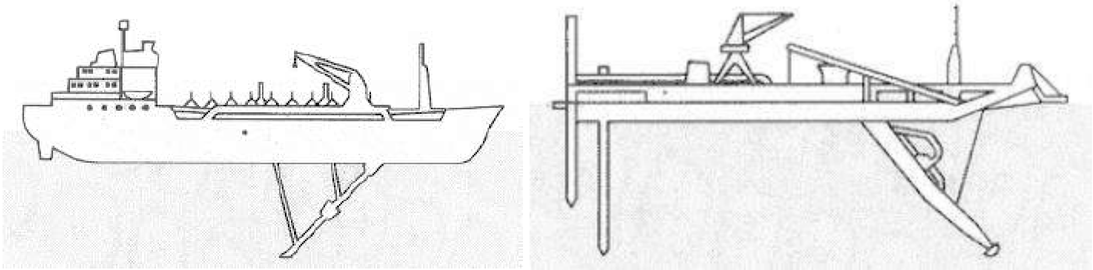

Source: VLASBLOM 2003

Figure 19: Schematic diagram of trailing suction hopper dredger (left) and cutter suction dredger (right)

Trailing suction hopper dredgers (TSHDs) consist of a self-propelled ship with a hopper equipped with one or two suction pipes connected to draghead(s) (see Figure 19). The dragheads are lowered to the sea- or riverbed and a slurry of sediment and water is pumped into the hopper. Dredged material settles in the hopper and the water drains off through a controllable hopper overflow system. Settlement of material in the hopper is dependent primarily upon grain size. Loading times can vary markedly for different sediments. For smaller dredgers of this type used on inland waterways, split hulled vessels are common in order to deposit the contents of the hopper on a placement ground.

During dredging, trailing suction hopper dredgers create turbid plumes as a result of the intake bypass, overflow and turbulence (caused largely by the ship's propeller). The bypass system is designed to prevent water being discharged into the hopper at the commencement and conclusion of dredging. Consequently, overflow of fine sediments is often restricted due to environmental reasons especially where there are sensitive resources nearby. Restrictions on the overflow of fine sediments may be justified on both environmental and economic grounds.

Cutter suction dredgers (CSDs) typically consist of a pontoon equipped with a rotating cutter head and an adjacent suction pipe that collects a mixture of cuttings and water which is pumped through a discharge pipeline to its destination (see Figure 19). Self-propelled and ocean going cutter suction dredgers do exist and are mainly deployed in capital dredging projects where significant quantities of rock need to be excavated.

The suction device captures most of the sediment removed by the cutter. Bigger sediment particles (partly disintegrated sediments) however, may be missed and fall back onto the sea- or riverbed. Their minimisation is a primary concern for both the dredging contractor and the contracting authority. Cutter suction dredgers have a high dredging efficiency and produce low turbidity at the cutter head. Thus it is uncommon for turbidity generated by the cutter head to cause environmental concern.

Mechanical dredgers: The most familiar type of mechanical dredgers is the backhoe dredger (BHD) and the grab dredger (GD). Both are mounted on a pontoon or self-propelled hopper, moored on anchors or on spud poles (see Figure 20). The backhoe dredger operates a bucket, with a size varying from a few m^3 to 20 m^3, mounted on an arm that is hydraulically operated. The grab dredger operates a wireline controlled grab. Another mechanical dredger is the bucket ladder dredger (BLD). It has a chain of buckets that rotate over a ladder (see Figure 20). Mechanical dredgers normally discharge into independent hopper barges, but are sometimes equipped as self-propelled vessels with their own hoppers.

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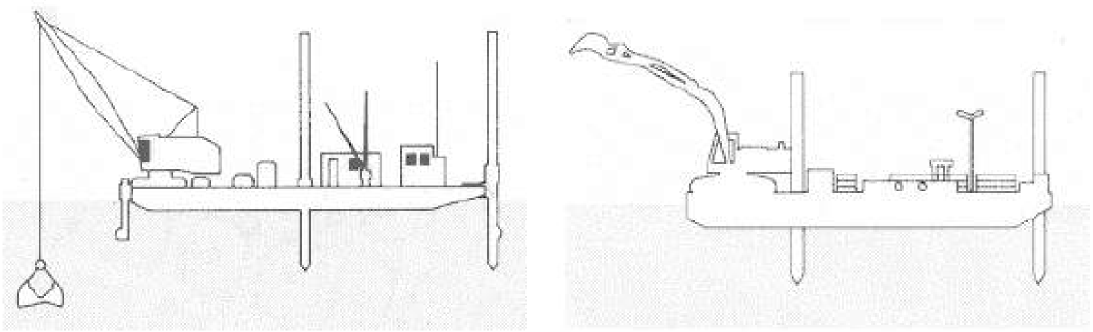
Grab dredgers may cause minimal disturbance and dilution of clays compared to hydraulic methods used by cutter suction dredgers and trailing suction hopper dredgers, but may cause high turbidity in loose silts where a significant fraction of the load may be washed out as the grab is hauled through the water. Mechanical equipment can reduce spillage and turbidity by limiting, e.g., hoisting speed and by avoiding overloading of open barges and hoppers. These are measures, however, that may reduce the production (output) of the equipment. The backhoe dredger has most of the advantages and disadvantages of the grab dredger, but can operate more quickly (see Table 1). Unlike a grab dredger, its maximum depth of dredging is limited by the length of its dredging arm. The bucket ladder dredger has a depth limitation and is normally working on anchor wires limiting the operability in confined spaces or spaces where anchor wires hinder other operations. It causes more noise than the other types of mechanical dredger. The advantages of the bucket ladder dredger are its ability to work continuously and its relatively high break-out forces both of which make it suitable to dredge more consolidated materials.



Source: Vlasblom 2003

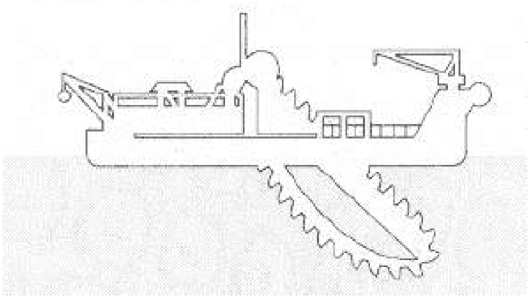


Figure 20: Schematic diagram of mechanical dredgers: grab dredger (top left), backhoe dredger (top right), bucket ladder dredger (bottom left)

A **sweep or plough bar**, also known as a "bed leveller" or "drag bar", consists of a large steel bar or open box which is dragged across the bed to level it out. The bar is suspended horizontally at a fixed depth from a barge and towed by a tug. This mechanical equipment is no dredger per se but can be used after dredging interventions in order to level the riverbed and thus to improve dredging results. There are other instances, however, where the sweep bar is used to drag sediment into a navigation channel (e.g. from a nearby access channel or restricted access area) for subsequent excavation by a trailing suction hopper dredger. It may also be used within areas where mechanical dredgers have been operating in order to achieve a minimum depth throughout berth areas without unnecessary dredging.

Table 1 shows a comparison of different dredging equipment in respect to its environmental conduct. The physical changes that can occur during the excavation of sediments are increased turbidity (generation of suspended sediments), mixing of soil layers, loss of excavated material (spill) and dilution (sediment mixing with water, especially in the case of hydraulic dredging).

Table 2 specifies the general possibilities of different dredger types as to the type of material to be excavated, the maximum dredging depth which can be achieved as well as the suitability of the equipment for dredging of in situ densities.

Table 1: Environmental conduct of standard dredging equipment (Source: PIANC 2009: 22)

Dredger	Safety	Accuracy	Turbidity	Mixing	Spill	Dilution	Noise
Trailing suction hopper dredger	+/0	–	–/0	–	0	–	+
Cutter suction dredger	+	+	0/+	0/+	0	0	+
Suction dredger	+	–	+	–	–	0	+
Backhoe dredger	–	+	–/0	+	+	+	+
Bucket ladder dredger	–	+	–/0	0/+	+	+	–
Grab dredger	–	–	–/0	0	+	+	+
"+" = better than average; "0" = about average; "–" = below average							

Table 2: Possibilities of different dredger types (Source: VLASBLOM 2003: 27)

Dredger	Dredging of sand	Dredging of clay	Dredging of rock	Max. depth [m]	Dredging of in situ densities
Trailing suction hopper dredger	yes	yes	no	100	no
Cutter suction dredger	yes	yes	yes	25	limited
Suction dredger	yes	no	no	70	no
Backhoe dredger	yes	yes	yes	20	yes
Bucket ladder dredger	yes	yes	yes	30	yes
Grab dredger	yes	yes	no	> 100	yes

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As can be concluded from both Table 1 and Table 2, backhoe and bucket ladder dredgers are suitable equipment for fairway maintenance dredging in free-flowing sections in the middle and upper reaches of natural rivers, while trailing suction hopper dredgers and suction dredgers are suited for dredging of small-grained sediments in the lower reaches of rivers.

Dredger selection

Dredging and material placement are site-specific activities. Dredger selection depends on a number of variables including:

1. Availability and cost, lead time to commencement of work at dredging site,
2. Physical characteristics of the sediment (soils with low cohesion, such as silt, sand and gravel, or cohesive soils, e.g. rock),
3. Contamination level of sediments,
4. Amount to be dredged,
5. Required accuracy,
6. Dredging site and water depth, flow velocity, discharge
7. Distance to the placement site,
8. Placement site and water depth, flow velocity, discharge
9. Physical environment at dredging and placement sites, accessibility to the site,
10. Weather and wave conditions, and
11. Method of placement.

The evaluation of environmental performance of specific dredgers includes the consideration of effects of the production rate, i.e. how many m^3 can be dredged with the selected equipment per hour/day/week/month, on the project duration, the levels of turbidity and suspended sediment concentrations generated relative to background levels, the proportion of total sediment lost to the environment and the degree of contamination in the sediment.

When dredgers are evaluated, all phases of the dredging operation (excavation, lifting, transportation and placement) should be considered as an integrated process. Typically, cutter suction dredgers show the least effect on turbidity at the dredging site (see Table 1) and trailing suction hopper dredgers produce similarly low turbidity when used without overflow. Grab dredgers and trailing suction hopper dredgers, when used with overflow, produce significantly higher turbidity throughout the water column near the dredging site than cutter suction dredgers. At the placement site, the reverse may be true. Mechanical dredgers do not disturb the structure of the dredged materials as much as cutter suction dredgers or trailing suction hopper dredgers do, which may fluidise sediments by mixing them with water. Fluidisation of clays by cutter suction dredgers and trailing suction hopper dredgers may cause discharged material to cover an excessive area when unconfined and fluidised sediments may take some time to consolidate, thus providing a source of ongoing turbidity until consolidation has occurred.

Consequently, suction dredgers may be preferred if the vicinity of the dredging site is particularly sensitive, while a mechanical dredger may be favoured if the vicinity of the placement site is sensitive. Dredging equipment itself leaves possibilities for technical adaptions to further increase the environmental performance of dredging projects (green valves, screens, curtains, animal deflectors, etc.).

The selection of the dredger to use for a specific fairway maintenance dredging intervention is mainly defined by the type of soil to be dredged and by the size and production rate of the equipment. Besides these criteria, the possibilities for transportation between the dredging and placement site are also relevant for dredger selection. Additionally, environmental criteria are to be taken into consideration, which is highly project specific. In the final selection the availability of specific equipment in the project area at the required time will be decisive.

Transportation and placement

In inland dredging the excavated material is mostly transported by barges, hopper barges or trucks which, if well maintained, keep the spill at a minimum until the material reaches its final placement site. If other equipment is used (e.g. pipelines) the impermeability of the equipment needs to be granted and checked frequently if indications of leakages occur.

At the placement site measures can be implemented to increase the control of placement and reduce spillage of material outside of the predefined site. The effectiveness of these measures is dependent on the conditions at the site and the capacity of the placement site in relation to the quantities and rate of supply of the material. Figure 21 displays conventional placement methods.

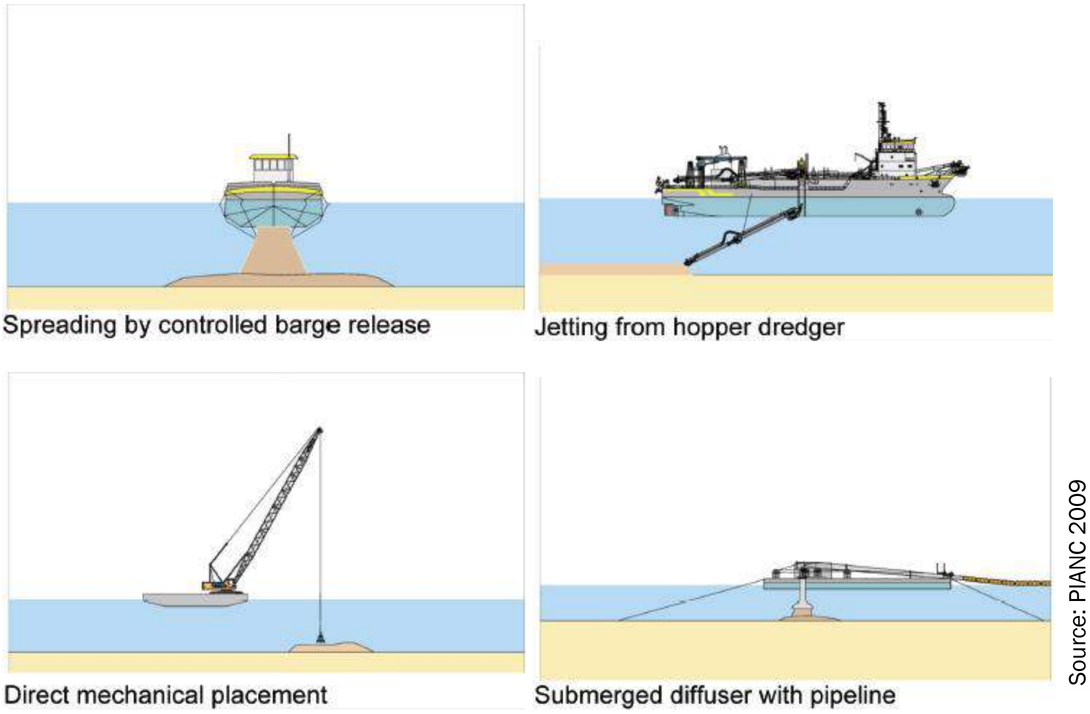

Figure 21: Conventional "controlled placement" methods (Source: PIANC 2009)

Materials that are transported hydraulically and directly placed in an open water site can cause significant turbidity plumes when placement is uncontrolled. Turbidity can be significantly reduced

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when the material is discharged close to the bottom and at low discharge velocities and water levels. This can for instance be realised by deploying split hopper barges, by jetting from hopper dredgers or direct mechanical placement or by applying a diffuser (also in combination with a pipeline).

Characterization of the environment and impact assessment

The severity of environmental impacts depends on the frequency, duration, magnitude and methodology of the dredging activity. Its influence on the composition and abundance of aquatic flora, of benthic invertebrate fauna and age structure of fish fauna is a major part of the impact assessment and needs to be quoted on a spatial and temporal scale. In addition to these biological components also hydro-morphological aspects have to be included in impact assessments. In regards to dredging activities these include the hydrological regime (quantity and dynamics of water flow, connection to groundwater bodies) and morphological conditions (river depth and width variation, structure and substrate of the riverbed and structure of the riparian zone) (EUROPEAN COMMISSION 2000: 34). The intensity of obliging assessments and entailing management practices is always site-specific and will vary between projects and project phases (implementation and post implementation).

During the implementation phase physical changes due to the dredging project will undoubtedly arise through the presence of the dredging equipment and excavation activities, sediment removal, altered morphology and re-suspension of sediment.

To obtain thorough baseline data, seasonal patterns with natural variations and long-term trends have to be included into the impact assessment. Without doing so it may be impossible to determine whether changes were caused by dredging activities, or not. These studies should be conducted by qualified scientific and technical personnel and should include public consultation cycles to eventually reduce possible user conflicts. Figure 22 depicts the interdependencies between ecological effects and dredging-related activities.

Characterization of the environment in which the dredging project will occur, design of the project, and monitoring during the work are fundamental scientific and engineering activities. Even though models help to facilitate understanding of complex problems it is advisable to also rely on expert judgement and recommendations, and take regulations into account. All the above states criteria have to be considered when appropriate management practices are identified.

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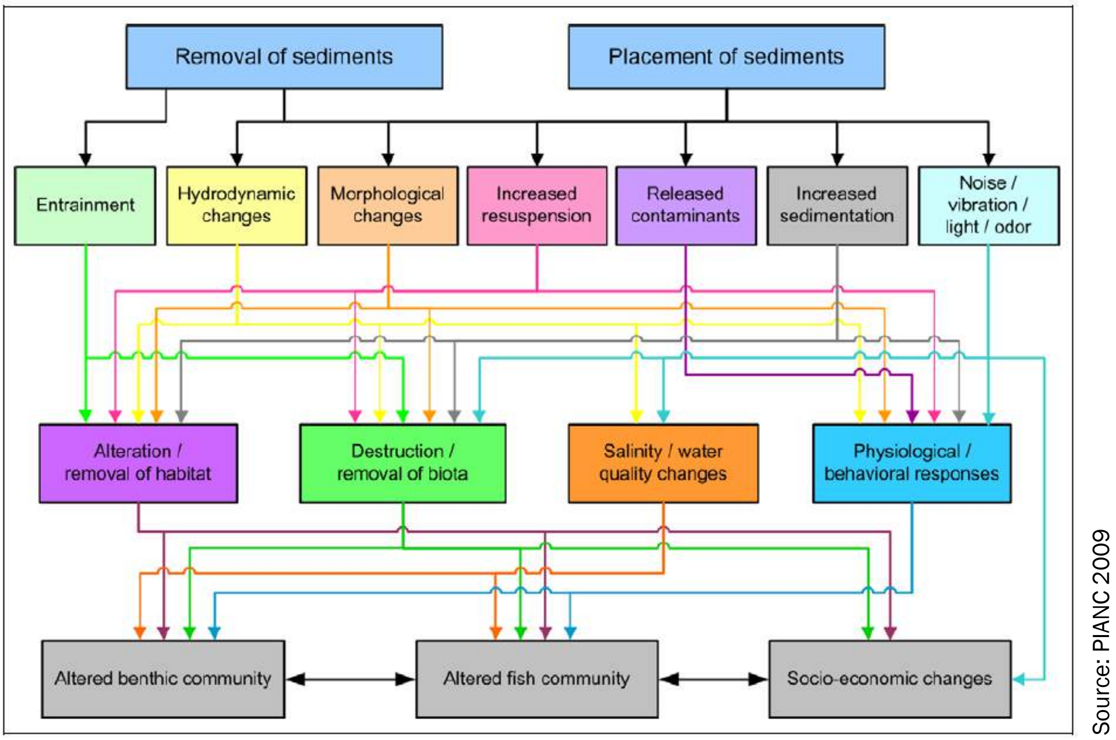

Figure 22: Conceptual model of physical changes and ecological effects from dredging-related activities

Identifying appropriate management practices

Management practices can be either related to a project or to a process. If the management practice is project-related, the strategic intent of the dredging activity is faced towards a positive environmental performance (contractor''s prequalification, construction monitoring program). A process-related management practice influences the inter-operational conduct such as equipment selection, modes of operation or institutional restrictions.

Identifying management practices which address risk association to a given project part is a strategic task. To screen and rank them according to their effectiveness, logistical feasibility and potential cost will support decision-making processes and leads to technically elaborated solutions.

Once the list of potentially applicable management practices has been reduced to those which are most likely to be feasible and capable of effectively preventing or mitigating the impact under question, the final selection of practices (i.e. best management practices determination) is made, seeking a balance between management practice implementation and the site specific nature of the project (e.g. spatial scale or sensitivity of the environment). PIANC 2009 offers a valuable toolbox for conducting the necessary steps (see PIANC 2009: 35–47).

It is wrong to assume that applying all possible management practices to a given project will lead to the best protection of the environment. In fact, indiscriminate application of management practices can actually have a net detrimental effect and can quickly render a project unaffordable and unworkable. It may therefore hinder sustainable development and its subsequent benefit for society.

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Monitoring and environmental compliance

Monitoring can determine whether the claimed outcomes of a dredging project were carried out according to contractual agreements or if they need corrective actions. It is important to define baseline conditions in advance to assure target comparability under different scenarios or changing natural conditions. The monitoring criteria are closely related to the requirements of the conceptual design or environmental impact assessment of a project. Threshold values can help the project management to interfere in ongoing activities if inter-operational feedback monitoring is executed in accorded reviews.

Environmental legislation may demand compensatory or mitigating measures connected to large maintenance activities but also provides financial assistance in case of extensive budgetary strains (co-financing). Mitigating measures in terms of waterway maintenance are accompanying projects which envisage the prevention of adverse ecological effects caused by human alterations to the structural and hydrological characteristics of surface waterbodies which are likely to arise during the construction or operation of an infrastructural asset such as loss of waterbody surface area, sound and noise pollution, discharge and flow velocity alteration, alterations in sediment regime or the input of hazardous substances. Mitigating measures are for example, the restoration of riverbanks through rip-rap removal, the establishment of stagnant water zones and gravel/sand structures, or the reconnection of side arms. In this respect, the European funds do, for example, co-finance compensatory measures within transport infrastructure project retained under the Trans European Network (TEN) or in order to achieve the environmental objectives set by the Water Framework Directive (WFD) (see BIZJAK ET AL. 2006 and EUROPEAN COMMISSION 2012a).

In this respect the EU's Financial Instrument for the Environment and Climate Action ("Life") supports actions in connection to the further development, implementation and management of the Natura 2000 network – in particular "the application, development, testing and demonstration of integrated approaches for the implementation of the prioritised action frameworks" (European Commission 2013a: 195).

6.3.2 Communication at all levels

International waterways are a complex matter as they traverse numerous countries and touch multiple interests. Due to this, administrations in charge of maintaining these waterways for navigation need to include stakeholders at various levels and from multiple fields of expertise at all stages of the continual improvement process.

Inclusive planning, monitoring and execution of measures is beneficial to waterway administrations in terms of a knowledge gain from related fields of expertise. It also supports a holistic perception of waterways. Traditionally, it facilitates a better understanding of issues related to navigation among the involved stakeholders and increases the acceptance of measures. Under such circumstances waterway management activities are easier to implement and more effective if they have been jointly developed and the involved stakeholders take ownership of widely supported ideas.

Depending on the phase of the fairway maintenance cycle (see Chapter 7), different interest groups are informed, consulted or invited to influence a decision. As an example, navigation as well as flood protection stakeholders usually need to be informed about the monitoring results. In order to gain an accurate picture of current fairway conditions, information from hydro-meteorological institutes is acquired. Ecologists, the responsible waterway management authorities, flood protection representatives and financial supports need to be consulted during the planning phase. The navigation industry may influence decisions related to the priority of measures.

6.3.3 Integrated planning approaches

Several waterway administrations in Europe have already applied such integrated approaches. In each case, the interplay between ecological and navigational aspects, as well as the integration of relevant user groups needs to be taken into account. The extent to which aspects such as social values (e.g. landscape, recreational value) are specifically included may vary.

Such a comprising, integrated approach cannot be generally considered as state of the art in all European countries. Two examples of Good Practices are the German "Framework Concept for Maintenance" and the Flemish "Sustainable Maintenance Plan Upper Sea Scheldt" (which is in its finalisation stage).

The "Framework Concept for Maintenance" (see BUNDESMINISTERIUM FÜR VERKEHR, BAU UND STADTENTWICKLUNG 2010) was prepared by the German Waterways and Shipping Administration (WSV) as a response to the implementation of the EU'S Water Framework Directive into national law in 2010. The framework concept addresses integrated maintenance strategies.

D) FRAMEWORK CONCEPT FOR MAINTENANCE ("RAHMENKONZEPT UNTERHALTUNG")	All federal waterways Germany
Problem/topic	
According to the Water Framework Directive (WFD), maintainance works should not lead to deterioration or put at risk the achievement of WFD objectives. The German authority integrated environmental objectives of new legislation into operational guidelines for integrated waterway maintenance on national level.	
Objectives	
• To achieve both transport-related and environmentally motivated goals through integrative maintenance measures. • To utilize expertise in the field of waterway engineering, navigation, hydrology, ecology, and environmental protection to create a coordinated program of measures.	
Background information	
The revised German Water Resources Act extended the responsibilities of the German Waterways and Shipping Administration (WSV) towards environmental objectives in 2010.	
Description of activities	
The German Waterways and Shipping Administration (WSV) addressed the need for integrated maintenance strategies by developing an extensive handbook on environmental issues related to federal waterways ("Handbuch Umweltbelange"). This handbook consists of several guideline documents, concepts and recommendations. Among others, it contains the Framework Concept for Maintenance ("Rahmenkonzept Unterhaltung"), which serves as an operational framework document for waterway maintenance activities of the WSV.	

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D) FRAMEWORK CONCEPT FOR MAINTENANCE ("RAHMENKONZEPT UNTERHALTUNG")

All federal waterways

Germany

The WSV illustrated the new implications for inland waterway maintenance that result from the revised Water Resources Act and the federal waterways law. Also factual and territorial scopes of application were examined. The framework concept analyses transport-related tasks and environmentally motivated ones, and identifies synergies and trade-offs between measures. The guidelines shall ensure that maintenance measures will be beneficial to both objectives. It contains practical examples for combined measures and ways to evaluate them. Also the need to prioritize measures due to financial constraints is addressed.

Users and stakeholders

- Planning, prioritization and implementation of measures related to inland waterways lies within the responsibility of the German Waterways and Shipping Administration (WSV).
- Environmental stakeholders (Federal Waterways Engineering and Research Institute – BAW, Federal Institute of Hydrology – BfG) contributed intensively to the development of the framework concept.
- The Federal States are responsible for the implementation of the WFD goals, including the development of River Basin Management plans. The WSV has to consider therein-stated water resource management measures. Hence, the relevant authorities are coordinating their work.
- The document takes the needs of waterway users (transport sector) and recreational users into account.

Key success factors and innovative aspects

- The framework concept was developed specifically for waterway maintenance measures.
- It addresses the interface between transport and environmental objectives in regards to maintenance activities and presents integrative guidelines for measures, and gives examples of combined measures too.
- Legal obligations and limitations are illustrated in detail and from a practical point of view.
- Key environmental stakeholders were integrated in the development process of the framework concept.
- The WSV closely cooperates with authorities responsible for WFD implementation and management plans in order to successfully develop and implement the guidelines.

Time frame and status

On 1 March 2010 the revised Water Resources Act came into force. The Framework Concept for Maintenance was published in July 2010. Today the concept is applied in the daily work of WSV and results in integrated measures under the above described premises.

There is a constant process of updating and improving the guidelines. The „Rahmenkonzept“ as such is not further updated. Since 2015, the „Leitfaden Umweltbelange bei der Unterhaltung“ is in place, where the important aspects are currently elaborated and specified. It is a practically oriented guidance for implementation.

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D) FRAMEWORK CONCEPT FOR MAINTENANCE ("RAHMENKONZEPT UNTERHALTUNG")	All federal waterways Germany
Lessons learned	
• An interdisciplinary approach creates synergies and enables that manifold goals are met with comparably little effort. • In order to successfully implement the goals of the WFD it is crucial that waterway administrations closely cooperate with authorities.	
Requirements for implementation in other Member States	
The Framework Concept for Maintenance is embedded in the legal framework of Germany and oriented on the local conditions of German waterways. However, the requirements are based on obligations due to European legislation. Thus, the document may be relevant to other European waterway administrations, too. Especially since so far no other similar guideline exists in any other country of the European Union. Member States can learn from the methodological approach of preparing integrative guidelines specifically targeted at waterway maintenance. There are practical examples of integrative measures. Guidelines ensure a quality standard for implementation of measures.	
Further information/contact	
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The "Sustainable Maintenance Plan for the Upper Sea Scheldt" is a Flemish plan that focuses on a specific stretch of the river Scheldt. It comprises long-term, environment-orientated management strategies in regards to enhanced performance of waterway infrastructure maintenance activities.

E) SUSTAINABLE MAINTENANCE PLAN FOR THE UPPER SEA SCHELDT	Upper Sea Scheldt Belgium
Problem/topic	
Currently, clear guidelines on bathymetric surveys, riverbank protection or conservation management of the tidal nature are lacking for the Upper Sea Scheldt.	
Objectives	
• To define specific objectives and a sustainable, comprising and nature-based management strategy within the "Integrated Plan Upper Sea Scheldt". • To dedicate a section of the plan to waterway maintenance (the "Sustainable Maintenance Plan") in order to guarantee a higher level of service by performing sustainable morphological and nautical maintenance activities.	

E) SUSTAINABLE MAINTENANCE PLAN FOR THE UPPER SEA SCHELDT	Upper Sea Scheldt Belgium

Background information

The surrounding areas of the Sea Scheldt are enlisted as Natura 2000 areas. The water depth of the Upper Sea Scheldt, and thus the level of service, is tide dependent. The maintenance plan only covers maintenance dredging and doesn't comprise widening nor straightening of the river.

Prior to the Integrated Plan, the main maintenance measures carried out by the Flemish waterway administration Waterwegen en Zeekanaal (W&Z) consisted of ad hoc dredging of the fairway based on reported damage, either by the districts or third parties. The district's staff stipulated the maintenance efforts accordingly, however clear guidelines on navigation, riverbank protection or conservation management of the tidal nature were lacking.

Description of activities

The plan ensures sustainable morphological and nautical maintenance. It consists of three sub-plans:

1. A sustainable bathymetry plan: Maintainable river sections, including targeted fairway conditions, were defined and measures to reduce environmental impacts were outlined. Considering the guidelines of the Dutch waterway authority Rijkswaterstaat, the reference water height (i.e. minimal water level for which a vessel is able to navigate without running aground) and the ECMT waterway class (a maintainable section for each area) was defined. Wherever possible, the resulting theoretical profile is fitted into the current bathymetry, if not, dredging works are proposed.

   Moreover, several measures will be taken into account to reduce the environmental impact, such as:

   - Combining dredging works with sand mining,
   - Optimising the sand mining locations,
   - Setting a maximum volume for the extracted material,
   - Dredging an overdepth in areas with quick sedimentation processes.
   - A monitoring protocol to evaluate the bathymetry was also established

2. A sustainable riverbank protection plan: This study established a framework to select the most suitable and sustainable bank protection strategy in the Upper Sea Scheldt. The main maintenance measure currently consists of ad hoc strengthening of the riverbanks by means of rip-rap, often resulting in overprotection of these riverbanks and increasing the surface of artificial substrates in the ecosystem. However, as this approach is expensive, the need arose for a more objective, sustainable and nature based management strategy. Hence, ecological riverbank protection is preferred. For locations where the tidal nature is at risk of eroding the riverbank, other forms of protection are defined.

   In this study sustainable bank protection is defined by optimizing ecosystem services, whilst guaranteeing flood control and navigation. The basic principles of the decision support system not only encompass the protection of the most vulnerable tidal freshwater marshes against erosion, but also allow for natural tidal marsh development where the system is wide enough.

E) SUSTAINABLE MAINTENANCE PLAN FOR THE UPPER SEA SCHELDT	Upper Sea Scheldt Belgium

Based on objective criteria (such as slope, width, current velocity) the type of bank protection is selected, taking advantage of the natural erosion-protection characteristics provided by tidal marshes. Hard bank protection is only selected if really required. If conditions permit, a natural undefended riverbank is preferred. Nature friendly bank protections (NFBP) provide an intermediate solution. The preferable bank protection measures have been sketched for the entire Upper Sea Scheldt. This "bank protection atlas" is compiled in a geographical information system (ArcGIS). Based on a monitoring protocol the need for servicing the bank zones is determined. Not only is this approach economically more advantageous, it also favours the conservation goals and good ecological status for the estuarine habitats.

3. A management and conservation plan for the tidal nature.

Users and stakeholders

- The plan was commissioned by W&Z and prepared by consulting firms and research institutes.
- Stakeholders integrated in the preparation process were waterway users, dredging companies, local governments, NGOs and environmental research institutes.

Key success factors and innovative aspects

Clear and integrated guidelines for navigational maintenance of the Upper Sea Scheldt have been developed within a strategic framework on the economic (transport) development of the river. Environmental issues have been considered specifically.

Time frame and status

- The development of the "sustainable bathymetry plan" started in 2014. Currently, it is undergoing environmental assessment; also construction permits are being evaluated. The plan shall be in operation by 2016.
- The development of the "sustainable riverbank protection plan" began in 2014. Its finalization is expected at the end of 2015.
- The development of the "management and conservation plan for the tidal nature" started in 2015. It shall be finished in 2016.

Lessons learned

No lessons learned yet, as the respective plans are not yet operative.

Requirements for implementation in other Member States

The only requirements are willingness and financial resources to create such integrated plans. Member States can learn from the methodological approach of preparing an integrated maintenance and management plan, taking into account various aspects of the fairway and its surroundings.

E) SUSTAINABLE MAINTENANCE PLAN FOR THE UPPER SEA SCHELDT	Upper Sea Scheldt Belgium
Further information/contact	
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6.3.4 Corridor-oriented approaches

Waterways are mostly international and cross several riparian states. Ideally, the fairway maintenance process should thus be designed in a cross-border and corridor-oriented way. Corresponding objectives need to be defined and enacted in cooperation within the implementation process. The international river commissions are key stakeholders in such activities (see Chapter 5.3).

A Good Practice Example with regards to a corridor-oriented approach is the joint fairway marking database by Croatia, Serbia, Bulgaria, and Romania (see Good Practice Example G on p. 81).

A further practical example for successful cross-border project activities is the bedload stabilisation project in the area of the village of Lobith and Spijk. There Dutch and German waterway management authorities implement joint maintenance activities to prevent erosion processes in the Rhine River.

F) STABILIZATION OF THE RHINE RIVERBED ALONG THE GERMAN-DUTCH STATE BORDER	Rhine The Netherlands, Germany
Problem/topic	
The progressive erosion of sediments in the Rhine river resulted in deepening of the riverbed and sinking water levels. This influenced fairway parameters and navigation negatively and also caused groundwater levels to sink. These dynamics also made it more likely for the Rhine to overflow its banks at high water levels, which increased flood risk. Without interventions, riverbed degradation would have continued and transformed the trough-shaped riverbed into a deep and narrow channel. The situation was particularly challenging due to the fact that the respective section of the Rhine coincides with the Dutch/German border and made cross-border project set-up and implementation necessary.	
Objectives	
• To stabilize the riverbed by stopping or delaying the erosion process on the German as well as the Dutch section of the Rhine. • To guarantee stable shipping conditions. • To reduce flood risk. • To stabilize groundwater levels	

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F) STABILIZATION OF THE RHINE RIVERBED ALONG THE GERMAN-DUTCH STATE BORDER	Rhine The Netherlands, Germany

Background information

Near the Dutch village of Spijk, between Emmerich (GER) and Lobith (NL), the centre of the Rhine river coincides with the Dutch-German state border for a distance of eight kilometres. Naturally, changes concerning the river affect both states.

In this section of the Lower Rhine, the river carries less sand and gravel than it would in a natural state. As a result, a problematic erosion in the riverbed has formed between Rhine-km 858 and Rhine-km 862, causing a waterway depth of more than 5 metres in some places.

To counter this trend, both riparian states initiated the projects "Sohlstabilisierung Spijk" and "Geschiebezugabe Lobith". For that purpose, the German WSV (Wasser- und Schifffahrtsverwaltung des Bundes) and the Dutch RWS (Rijkswaterstaat) agreed to cooperatively stabilize the riverbed and balance the bedload deficit.

Description of activities

For the "Sohlstabilisierung Spijk" – the project to stabilize the riverbed near the Dutch village of Spijk - 454,000 tons of building material was transported to the site. 200 shiploads were necessary for the transport. WSV also used a vessel equipped with a harrow to level the riverbed after insertion of the material. Within 16 months the entire building material was placed, using 268,000 tons of coarse stones as top cover. The construction work was done in sections of approximately 200 metres, starting at the lower end of the construction sector and moving upstream. The whole process was constantly surveyed in order to evaluate the measures. The German Federal Waterways Engineering and Research Institute (BAW) confirmed that the project also reduced flood risks.

In course of the project "Geschiebezugabe Lobith" the waterway authorities will place sediment into the Rhine near the Dutch village of Lobith to balance the bed load deficit.

Users and stakeholders

- The projects were initiated and implemented by the governmental waterway administrations: The German Wasser- und Schifffahrtsverwaltung (WSV) and the Dutch Rijkswaterstaat (RWS). The states share the costs (total: 24 million Euro) equally.
- Representatives of other organisations and interest groups (especially environmental organisations and institutions dealing with flood protection) took part in the process

Key success factors and innovative aspects

Both Germany and the Netherlands accept their responsibility to provide good navigation conditions on the Rhine. By cooperating, they have overcome legislative, organisational and language problems and succeeded in planning and implementing measures on the territory of a neighbouring state.

Time frame and status

The project objectives are contained in the framework agreement "Grenzstrecke NL/D" of 30 May

F) STABILIZATION OF THE RHINE RIVERBED ALONG THE GERMAN-DUTCH STATE BORDER	Rhine The Netherlands, Germany

2007. On 28 May 2008 an agreement between WSV and RWS entitled "Unterhaltungsarbeiten in der gemeinsamen Grenzstrecke des Rheins" ("maintenance works on the common border stretch of the Rhine") was signed. The document contains the rights and duties of the parties.

The stabilization of the riverbed near Spijk is already completed. The construction works of the project "Geschiebezugabe Lobith" are expected to start in 2016.

Lessons learned

The managing authorities had to deal with several challenges such as:

- Language barriers: For the translation of technical-hydrological language an interpreter had to be hired.
- National law: Both authorities had to adapt statutory provisions and approval procedures to enable implementation of the project
- Questions regarding taxation: Where shall value-added-taxes be discharged if a working group of a German and a Dutch company works on state territory of The Netherlands in the context of a project of German administration? Intensive discussion with German and Dutch (tax-) authorities and tax accountants solved these questions.

Requirements for implementation in other Member States

This project serves as an example for water engineering projects in border regions of other Member States. It shows that typical problems of projects touching the territories of two (or more) countries can be solved by common objectives and good communication.

Further information/contact

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7 The fairway maintenance process

Waterway and fairway maintenance activities are – contrary to structural river engineering measures – of a recurrent and continuous nature. Hence these processes can be visualised in the form of a "fairway maintenance cycle" (see Figure 23).

Any kind of infrastructure maintenance management is defined by a number of targets and certain steps or modules in a circular process leading to a constant improvement based on an analysis of previous experience and results (see Chapter 6.2). For fairway maintenance the basic process consists of monitoring and surveying of infrastructural (fairway) conditions, an assessment of current conditions and an estimation of possible developments as a basis for planning and optimisation of necessary maintenance or river engineering measures (NEWADA DUO 2014a).

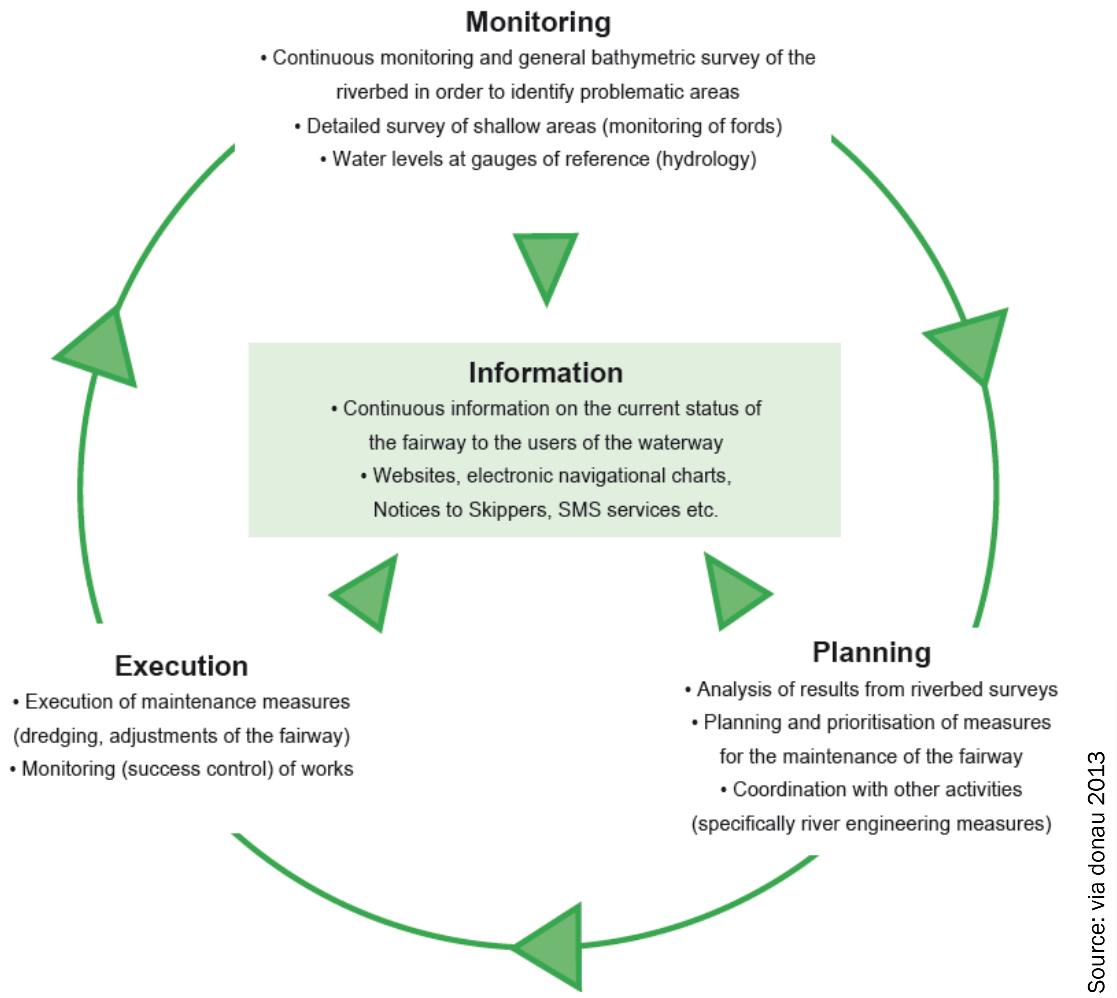

Figure 23: The fairway maintenance cycle

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The steps or modules in the circular fairway maintenance process include:

- Regular (bathymetric) surveys of the riverbed, monitoring of hydrological conditions and fairway marking in order to identify critical areas in the fairway (reduced depth and width or curve radius),
- Examining the potential of structural river engineering measures to reduce maintenance efforts in those critical locations which are characterized by high sedimentation rates,
- Planning and prioritization of necessary interventions (e.g. dredging measures, relocation of the course of the fairway, marking of the fairway) based on the defined targets and the analysis of up-to-date hydrographic surveys,
- Communication of measures to stakeholders, especially waterway users, and including their feedback into future plans,
- Execution of maintenance works (including success control and evaluation of effects),
- Provision of continuous and target group-specific information on the current state of the fairway to the users of the waterway.

Any infrastructure maintenance cycle always starts with an inventory and survey of the current conditions. The optimal frequency of any kind of riverbed survey is found if the additional costs for surveys are not outweighed by the benefits of better decisions based on these additional surveys (see Chapter 7.1, **Status monitoring**). The subsequent processing capacity for surveying results depends on the length of a river section and the equipment used. The time frame for result processing may range from one day to several weeks.

For any kind of decision process regarding the implementation of fairway maintenance measures, an assessment and estimation of possible condition development with and without measures is crucial. A comparison and optimization of all technically feasible measures as a result, e.g. in the form of a "measure decision tree", is therefore only possible if both costs and impacts (duration) are known. The central question in this respect: Which improvement might be attained with which type, extent and costs of measures and for which time frame? This approach is impact-oriented and clearly focuses on the improvement of fairway availability (see Chapter 7.2, **Planning measures**, and Chapter 7.3, **Executing measures**).

Setting priorities for measures on transport infrastructures basically involves a ranking, e.g. regarding the highest negative impact on infrastructure users, the worst condition compared to a target level of service or the highest monetary losses due to malfunction. Typical priorities regarding fairway maintenance are given to measures on shallow sections with the lowest fairway depth at low water levels. Additional criteria may be the remaining fairway width with sufficient depth and/or the rate of sedimentation on critical bottlenecks based on an estimation of remaining time until the section cannot be passed (see Chapter 7.4, **Evaluation of measures**).

In general, management and implementation of fairway maintenance on a dynamic river with constantly changing riverbed morphology and water levels on a length of a few hundred kilometres is in itself a very demanding task. For skippers and navigation companies, however, the taken maintenance approach does not matter as long as continuous fairway conditions and actual reliable and accessible information on the current state of the fairway are provided. With this information available, navigation companies can calculate with lower safety margins leading to a higher load factor of vessels throughout the year (see Chapter 7.5, **User integration and information**).

This concept can be seen as a guideline for integrative waterway maintenance. It is applicable in the majority of European waterway corridors.

7.1 Status monitoring

The choice and design of suitable (maintenance) measures is only as good as the data by which the decisions are made. However, many administrations are confronted with an insufficient knowledge base that limits them in designing and implementing the best possible measures.

In general, fairway-related monitoring needs to address the following elements:

- The river's geometry and morphology (longitudinal and vertical profile, sediment transport, slope, etc.),
- Water discharge and water levels,
- Fairway marking,
- Fairway-related infrastructure (groynes, training walls, rip-rap, etc.),
- Ecological factors, especially all quality elements of a water body according to the WFD (Annex V) in order to assess (non-) deterioration of its status.[14].

7.1.1 Geometry and morphology: Bathymetric surveying

Bathymetric surveys are conducted by survey vessels that are equipped with specific measuring devices which gather information on riverbed morphology (water depth, riverbed conditions, etc.). This information may be used by waterway administrations, pier and port operators, electricity producers, etc. Through bathymetric surveys they can monitor riverine erosion and sedimentation processes which might trigger the necessity of maintenance interventions (e.g. removal of excess sedimentation in the fairway, in port entrances or in the immediate vicinity of locks, protection against scouring at river engineering structures or barrages).

There is potential in coordinating **navigation related bathymetric surveying** with **sediment monitoring** that is done within **ecology-related river basin management.** This would result in cost savings and better data on both sides. Coordination of maintenance plans and River Basin Management Plans would be a promising next step.

Measuring equipment

The basic device for bathymetric riverbed surveys is an **echo sounder**. It uses sonar technology to measure physical conditions underwater by directing sound pulses vertically from the vessel down to the riverbed at a rate of milliseconds, measuring the distance by means of time interval between transmittance and reception.

[14] Ecological monitoring is not the focus of this Manual and is therefore only addressed briefly.

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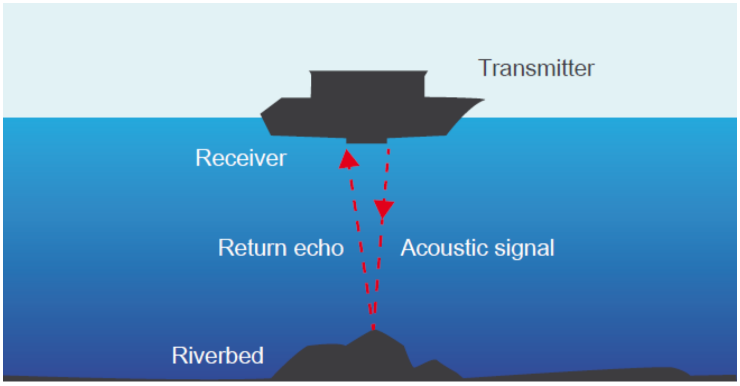
The two main bathymetric systems for riverbed surveys based on echo sounding technology are single-beam and multi-beam methods. This data is the basis for the calculation of riverbed isolines that are used to display the riverbed and current fairway conditions.

Single-beam bathymetric systems are generally configured with a sonar transducer mounted to a survey vessel, which turns an electrical signal into sound (transmitter) and converts sonar pulses back into electrical signals (receiver). By using single-beam technology only water depths directly beneath the survey track of the vessel can be measured. Consequently, the water depth is known for cross- or longitudinal profiles only, values in between are usually interpolated on the basis of a mathematical model.

When transmitting in downstream direction, the vessel is usually navigating in the middle of the fairway, which is normally corresponding to the thalweg of the river. At critical sections this longitudinal profile can be rounded off by additional survey tracks close to the right- and left-hand margins of the fairway in order to gain a more detailed picture of problem areas. When surveying a cross-profile, the vessel moves back and forth between two fixed land-based points. As the riverbed's morphology is not fully covered by a single-beam survey, the amount of data is lower, but allows for faster and cheaper data gathering and processing as compared to multi-beam surveying. Waterway administrations generally use single-beam technology to gain a quick overview on shallow river stretches and to identify areas in need of further investigation.



Source: via donau 2013

Figure 24: Schematic operation of a single-beam echo sounder

Multi-beam bathymetric systems are used in order to obtain full coverage of a riverbed. The multi-beam sonar system has a single or a pair of transducers, which continually transmit(s) numerous sonar beams to the riverbed in a swath- or fan-shaped signal pattern. This makes multi-beam systems ideal for a complete mapping of smaller areas as this kind of bathymetry yields 100% coverage of the riverbed's morphology. For easier data handling and processing multi-beam data can be thinned.

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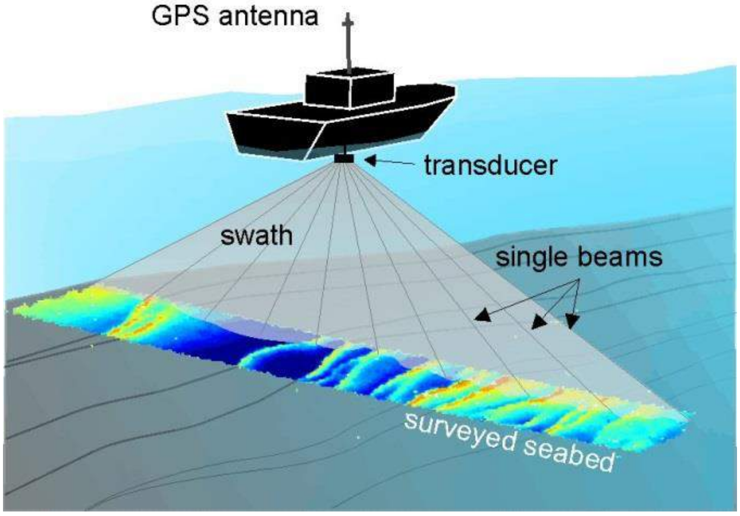


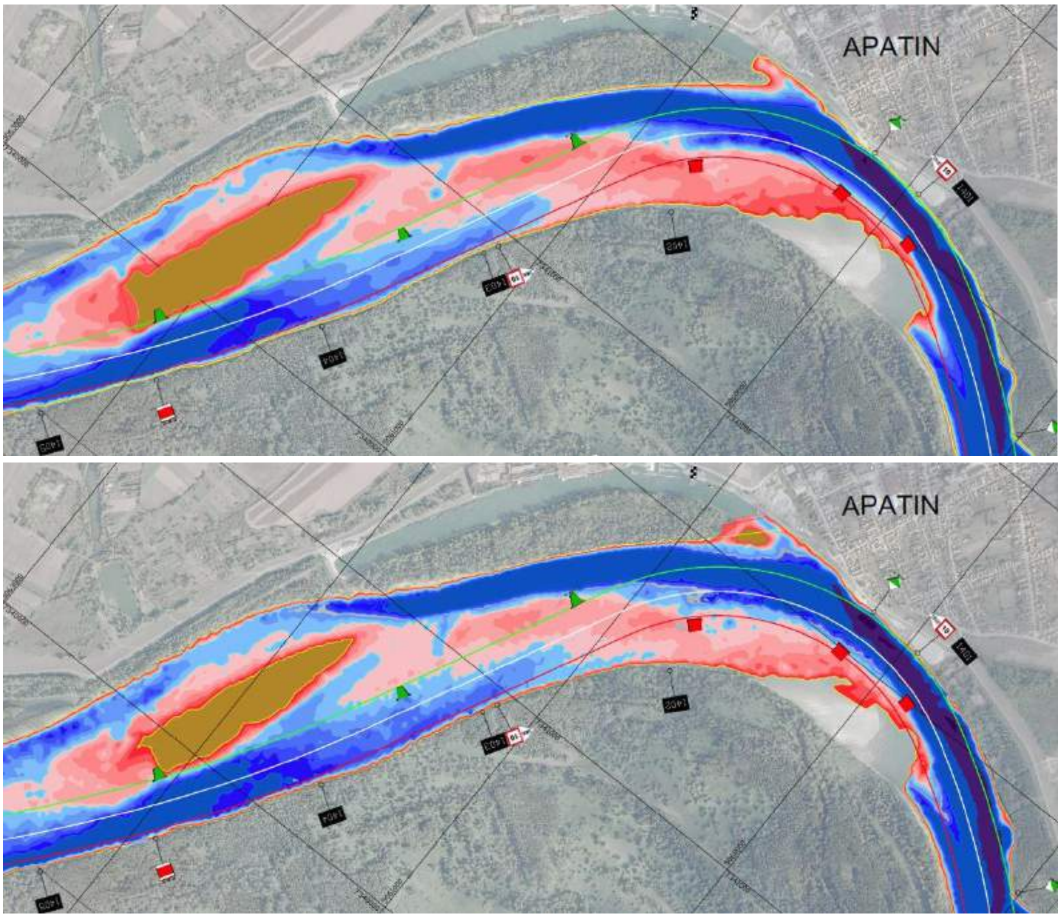
Source: MARUM – Center for Marine Environmental Sciences, University of Bremen; C. Wienberg

Figure 25: Multi-beam riverbed survey

As multi-beam surveys are more time-consuming, especially regarding the post-processing of results, and are also more complex than single-beam surveys waterway administrations use this technology as basis for detailed planning and monitoring of dredging works as well as complex tasks such as searching for sunken objects or research activities (VIA DONAU – AUSTRIAN WATERWAY COMPANY 2013).

Source: via donau/Andi Bruckner

Figure 26: Multi-beam survey vessel on the Austrian Danube



Source: Plovput

Figure 27: Comparison of single-beam (top) and multi-beam (bottom) surveys performed by Plovput in 2009 for the critical section "Apatin" on the Serbian stretch of the Danube

Basic requirements for survey vessels are high manoeuvrability and low draught, enabling them to access most areas of the river.

In matters of hydrographic surveying equipment, rotating dual head sensors are advised, as they enable projection of wider shallow water areas. Consequently, a larger area can be covered and monitoring expenses decreased. Depending on the analysis tools, the effort for data elaboration to displayable charts also decreases, which eventually reduces the time of information transmission to navigators and skippers (VIA DONAU – AUSTRIAN WATERWAY COMPANY 2011).

Regarding the accuracy of hydrographic measurements performed either by single- or by multi-beam equipment, certain error limits should be observed in order to obtain a sufficient quality level. In terms of the positioning accuracy of soundings (easting/y-axis and northing/x-axis), a value of +/- 0.20 m is recommended. For depth accuracy (z-axis), +/- 0.05 m should be achieved.

Bathymetric surveys are complex and require specialized equipment and well-trained staff. An innovative approach to complement these surveys may be the use of conventional vessels which are equipped with an echo sounder. As data received from echo sounders for real-time depth measurement is usually not stored, a data storage device in combination with a positioning system could be installed on board in order to enable the storage and post-processing of this **floating ship data**. A pilot solution was investigated in the NEWADA duo project (including consideration of the commercial COVADEM application) (see NEWADA DUO 2014d). Further investigations regarding the implementation of such a system are currently ongoing in the research project PROMINENT.

It is a clear advantage that any ship could be equipped with the necessary tools and thus collect depth data automatically. Both, ships of waterway administrations (e.g. marking vessels) and navigation companies (freight or passenger vessels) are suitable for this purpose. Only water depths directly underneath the ships are measured, but if a critical mass is reached the approach could be a valuable source of up-to-date information on current fairway conditions. Especially countries struggling with limited resources and equipment for precise, frequent and regular bathymetric surveys are advised to consider this concept. However, costs for equipment (positioning and on-board data storage) and ship-to-shore data transfer and database post-processing are high. Furthermore, the need to develop ways to use and provide the information remains a challenge.

Measurement schedules

Two types of measurement schedules for hydrographic single- and multi-beam surveys can be identified: (A) periodically recurring measurements of river sections for the purpose of basic monitoring and (B) project- or event-related measurements which might be more detailed and are usually limited to smaller areas and a shorter period of time. The schedules need to be adapted to specific river stretches depending on their hydro-morphological characteristics.

As a basic orientation the following guidelines can be provided in regards to periodic and event-related measurements:

A. Periodic measurements for basic monitoring

These "standard measurements" are conducted in recurrent manner, usually in temporally fixed time slots over the year. They are dedicated to controlling and documenting the basic changes in the morphology of the riverbed.

1. Regular survey of complete waterway

Cross-sectional and longitudinal profiles of the entire river stretch should regularly be gathered by single- and multi-beam surveying in order to provide the necessary and actual basic information on the conditions of the waterway.

The required distance between single-beam profiles is dependent on the conditions of the respective river stretch. Critical, i.e. shallow and/or narrow sections that are relevant for fairway availability of course require a higher density compared to non-critical sections. Characteristic sectors which should be monitored as part of a regular survey may include movable sand or gravel bars, sections with a rocky riverbed, mouths of tributaries, river bends or bridge spans.

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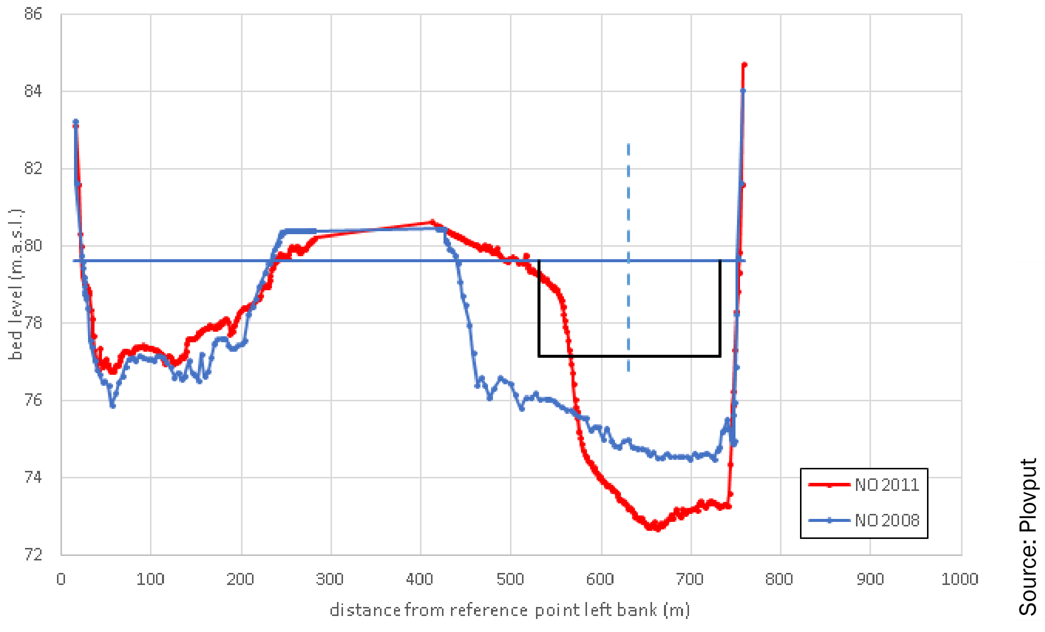

Figure 28: Fairway profile (cross section) of the critical section "Apatin" on the Serbian stretch of the Danube, river-km 1,404.00: comparison of riverbed morphology in 2008 and 2009

2. Regular survey of critical sections

It is advisable to survey critical fairway sections (e.g. fords and lateral sediment accumulations) in greater detail before recurrent low water periods (see Chapter 6.1.2 on proactive fairway maintenance). A sufficiently long time period should be available between these surveys and actual fairway maintenance works (should the latter be necessary). Especially dredging interventions should be performed prior to low water periods in order to be able to provide waterway users with sufficient fairway parameters during the low water period. Dredging during low water periods is not effect-targeted, as enhanced fairway parameters are needed by waterway users especially during and not at the end or even after these nautically critical periods. Low water periods vary depending on the specific waterway.

In order to monitor the development of critical sections, establishing and updating a catalogue that contains the basic information on those sections is advised. Such a catalogue is an essential prerequisite for the prioritization of interventions and also facilitates coordination with further navigational and administrational authorities in day-to-day operation.

3. Frequent checks of highly critical sections

Depending on the morphological dynamics prevailing in certain river stretches, additional checks of critical sections with simple equipment (standard echo sounder or single-beam) should be undertaken in a relatively high frequency in order to verify changes in a continuous manner. This frequency can be in the range of every two weeks/every month in sectors with higher slopes and fluctuating water levels in the upper reaches of a river to every quarter/every half year in the middle and lower reaches of a river where slopes are rather low and fluctuations in water levels less distinct. A frequent deviation analysis enables quick or even pro-active action and eventual reappraisal of critical sections or the identification of new ones.

In periods with low water levels it is advisable to survey the most critical locations in a river section in a higher frequency (i.e. weekly or monthly soundings), depending on the characteristics of the river section in question. In low water periods, this hydrographic information is essential for the users of the waterway (skippers, shipping companies, forwarders etc.) as it yields an actual picture of the navigational status and directly affects the decision of how many goods can be loaded per vessel (in periods with higher water levels, vessels can be loaded to 100%). Survey results will of course also contribute to the prioritization of critical sections and trigger maintenance works (see Point 2 above).

4. Quality control of interventions

Prior to and after performance of dredging measures the project areas should be surveyed via multi-beam sounding equipment in order to assess the effectiveness of measures in detail. For dredging interventions which last over several weeks, an intermediate hydrographic survey might be useful in order to judge the dimension of bed load supply into the dredging area and to monitor progress of works. For a more detailed account regarding the evaluation of fairway maintenance measures, see Chapter 7.4.

B. Project- or event-related bathymetric measurements

1. Riverbed assessment related to dredging projects is performed to calculate the necessary cubature to be dredged at a critical location as well as to validate project success. Furthermore, it preserves evidence for the correct handling of dredged material.

2. Long-term analyses of the development of critical sections enable cost-benefit comparison between ongoing maintenance works and the construction of river engineering structures for low water regulation, like groynes and training walls. The establishment of effectivity indices facilitates this comparison.

3. Ports and port entrances as well as areas up- und downstream of locks and bridges are as important for commercial navigation as the fairway itself and need continuous monitoring. If shallow areas are detected through bathymetric surveys, maintenance measures are required. These are carried out by the respective responsible authority (e.g. waterway authorities, hydropower companies, municipal authorities). In order to attain comparable waterway infrastructure parameters, coordination between the involved players is crucial.

7.1.2 Water levels and discharge: Hydrological measurements

Observation of hydrological conditions is another essential element in fairway monitoring processes. Water level fluctuations in natural waterways occur as a result of differences in discharge. Sea estuaries are also influenced by tides, seasonal variations, wind setup, translation waves, etc. Water level variations also occur – with less intensity – in canals with a so-called fixed canal water level.

Water levels, in combination with data from hydrographic surveys, enable the calculation of fairway depths and are therefore of crucial importance for waterway users. The current fairway depth at a certain location can be calculated if the current water level at a nearby reference gauge and the minimum fairway depth relative to the respective reference water level (e.g. low navigation and regulation level) are known. This correlation is visualized in Figure 29.

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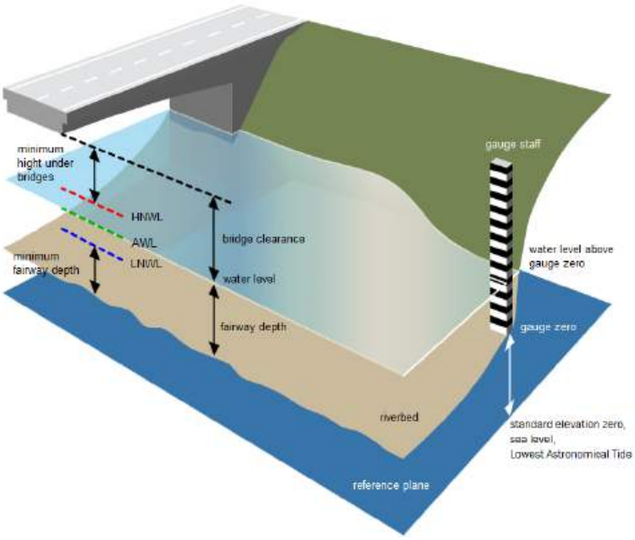

Water level above gauge zero

− Low navigation reference level

\+ Minimum fairway depth

= Current minimum fairway depth

Source: Xavax

Figure 29: The relation of water levels and fairway depth

Waterway administrations refer to statistical reference values for water levels at gauges when planning maintenance activites or designing river engineering works. High water levels serve as the base for headroom calculation, while low water levels do for fairway depth.

For inland waterways, these reference water levels are corresponding water levels at different cross sections which show the same annual percentage of higher and lower discharge deviation. Depending on the respective waterway, the average values are calculated over a reference period of several decades for inland waterways. Updates of reference water levels need to be performed regularly, e.g. every 10 years.

The reference water levels of the rivers and river sections that are addressed in this Manual are depicted in Table 3. Reference water levels of the tidal Sea Scheldt do not yet exist, but are currently under development by the Belgian waterway administration.

Table 3: Reference water levels at rivers Scheldt, Rhine and Danube

Sea Scheldt	*Rhine*[15]	*Danube*[16]
Reference Low Water Level (MLW) *For the Sea Scheldt, no reference water level is existing at the moment. The Flemish waterway administration is currently working on a definition.*	**Equivalent Water Level or "Gleichwertiger Wasserstand" (GlW)** The water levels corresponding to water levels that occur to equivalent low discharges with a underrange period of 20 days along the Rhine, over a	**Low Navigation and Regulation Level (LNRL)** Water level corresponding to a discharge reached or exceed on 94% (343 days) of days per year on average, over a reference period of 30 years (currently from 1981 to 2010),

[15] Wasser- und Schifffahrtsverwaltung des Bundes 2014.

[16] via donau – Austrian Waterway Company 2013.

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Sea Scheldt	*Rhine*[15]	*Danube*[16]
The Dutch waterway guidelines can serve as example. MLW and MHW (see cell below) are defined in the following way: On canals and in the event of short-term water level variations, e.g. in tidal areas[17]: the water level that is not exceeded 1% of the time, measured over the past ten years. In the event of long-term water level variations, e.g. in rivers: the water level that has not been exceeded only once for a consecutive period of 24 hours in the past ten years.	reference period of the preceding 100 years.	excluding periods with ice.
Reference High Water Level (MHW) On canals and in the event of short-term water level variations, e.g. in tidal areas: the water level that is exceeded 1% of the time, measured over the past ten years. In the event of long-term water level variations, e.g. in rivers: the water level that has been exceeded only once for a consecutive period of 24 hours in the past ten years.	**Highest Navigation Water Level (HNL)** Reference high water levels at gauges relevant for navigation which are defined by the competent authorities and which are valid for a specific waterway section. These reference values are dependent on local conditions and vary for different waterways.	**High Navigation Level (HNL)** Water level corresponding to a discharge reached or exceed on 1% of days per year on average, over a reference period of 30 years (currently 1981 – 2010), excluding periods with ice.

Stream gauging is the process of measuring the water discharge at a particular point on a stream or river. Measuring discharge (Q) directly is challenging so stream gauging is typically done by measuring both, the water velocity (V) and the cross sectional area (A). The discharge or water flow is then calculated with the use of the equation $Q = V \times A$.

Measuring equipment

[17] Rijkswaterstaad Centre for Transport and Navigation 2011.

Water levels are regularly measured at gauging stations. Nowadays automatic gauging stations are used most often. They need electricity supply for constant operation which can be provided by a connection to the public power supply grid or in remote regions by a solar panel. Access to the GSM network is necessary in order to provide uninterrupted data transmission. Non-automatic gauging stations record water levels without transmitting them or do not store data at all. In this case values have to be collected manually on site.

The water velocity needed to calculate the discharge (Q in m^3/s) can be measured in several ways. The most popular way is the use of a water velocity or current meter. Another method is the Doppler Meter. It uses sound waves to measure the velocity of particles in the water.

Measuring schedule

Sensors of automatic water level gauges may detect the water level every minute before submitting an arithmetic mean value for a period of 15 minutes to a water level database.

Stream gauge measurements are usually undertaken manually and are not suitable for collecting continuous data. Typically, water levels are used as substitute measurements. As the discharge of a river is directly related to the height of the water, a rating curve can be elaborated by taking regular spot measurements under different water level conditions. The more data points are collected the more accurate the stream gauge rating curve will be.

7.1.3 Fairway marking: Monitoring of fairway marking

Figure 30: Red and green buoy with radar reflector for marking the fairway (Source: Plovput)

The traditional way of marking the course of the fairway by means of floating marks, e.g. buoys or spears, is a well-known and established system (see Figure 30). The marks are easily seen and interpreted under good visibility conditions, without the need of any on-board equipment or data transfer. This kind of marking system is typically monitored via visual inspection.

A disadvantage is that although a real buoy with a radar reflector is visible on the radar screen, the type (colour) of the buoy cannot be unambiguously identified. Furthermore, deviations of the position cannot be automatically detected.

New concepts based on surveillance of aids to navigation (AtoNs) via Inland AIS technology (Automatic Identification System) are currently under discussion. In the maritime sector, AIS AtoNs are already state of the art. Inland AIS is a communication system between ships and between ships and shore, providing position, identity and other navigation data of a ship. Recently, this technology is being tested to provide information on aids to navigation (AtoN), e.g. buoys as well.

In this case, a special AIS Aids to Navigation Report message ("AIS AtoN") transfers type, name, position of the AtoN as well as information if the floating mark is on the required position or not (off position). This AIS AtoN report message can be either transmitted by a specific AIS AtoN station mounted on a buoy or by an AIS shore station. Ships equipped with an appropriate display system like ECDIS (Electronic Chart Display and Information System) may display the information contained in the AIS AtoN report message, e.g. as a symbol on the chart at the reported position of the AtoN. This functionality still needs to be standardised and is not yet implemented in all ECDIS applications.

There are three basic systems of AIS aids to navigation:

1. Real AIS aids to navigation

An AIS station is located on an AtoN which physically exists, e.g. which is mounted on a buoy. It broadcasts real time data about the type, name, position and the status (e.g. on/off position) of that buoy under all visibility conditions for all vessels equipped with AIS and electronic charts. It allows waterway administrations to identify problems like drifting, theft or collisions with/damage caused by vessels.

Among the disadvantages of the system are the installation costs for AIS buoys and the data transfer load. Furthermore, problems displaying the position of the floating marks may arise. These could be minimised by improved standards.

2. Synthetic AIS aids to navigation

The AtoN message is transmitted from a remote AIS station to the AtoN. This system offers the same advantages as the real AIS AtoN, but the implementation costs are lower (no GPS equipment necessary on the buoy). However, due to the additional communication link, the operating costs are higher and additional malfunction risks of the AtoN transmissions exist.

3. Virtual AIS aids to navigation

A "virtual AIS AtoN" message is transmitted by an AIS shore or AtoN station for an AtoN that does not physically exist. The AtoN symbol or information is available for presentation on an electronic navigational chart, even though there is no real AtoN such as a buoy or beacon.

This system offers the same advantages as synthetic AIS AtoNs. Additionally, position changes of a buoy e.g. in cases of incidents can be implemented faster by using a virtual AIS AtoN instead of a real buoy. However, a precondition for the use of virtual AIS AtoNs is the seamless availability of Inland AIS and Inland ECDIS in Navigation Mode on all vessels, which would result in significant costs. In case of failure of the system, no information about virtual AtoNs would be available. Furthermore, amendments to relevant police regulations would be necessary to allow for replacing real buoys with virtual AIS AtoNs.

The RIS Expert Group on Vessel Tracking and Tracing has stated that the use of AIS AtoN messages in combination with real buoys may have benefits for both skippers and administrations. However, it has to be considered that not all vessels might be equipped to display AIS AtoNs and the availability and reliability of the AIS information cannot be guaranteed in all cases. It is advised to evaluate the usefulness of AIS AtoNs on a case-by-case basis as it depends on the local situation and conditions. Preconditions are the amendment of standards, investments in shore and on-board infrastructure and the implementation of pilot projects.

The use of virtual AIS AtoNs as replacement for real buoys is not recommended, as it is not (yet) feasible to equip the whole fleet including pleasure crafts with AIS and Inland ECDIS in Navigation Mode. Still local tailor made solutions using virtual Aids to Navigation might be implemented.

Within the FAIRway project a concept for the application of AIS AtoNs will be elaborated and shall be followed by a decision from the RIS Expert Groups on VTT and Inland ECDIS. It is recommended to await the outcomes before investing in one of the AIS AtoN systems.

Croatia, Serbia, Bulgaria and Romania have created a corridor-oriented fairway marking database. This joint monitoring of the fairway marking signs is considered as a Good Practice Example.

G) CORRIDOR-ORIENTED FAIRWAY MARKING DATABASE	Danube Serbia, Croatia, Bulgaria, Romania
Problem/topic	
Currently, seven countries and nine different waterway administrations are responsible for fairway marking along the Danube. A number of river stretches are under shared responsibility, which makes the situation even more complex. Different approaches towards visualizing and publishing marking data as well as different standards for updating periods of coastal and floating signalization create the need to harmonize procedures related to waterway marking.	
Objectives	
• To apply a corridor-oriented approach: Harmonizing marking information along the Danube waterway by a common database and unique visualization standards for Croatia, Serbia, Bulgaria and Romania. • To create easy access to information through joint management and publication of the coastal and floating signalization data on http://marking.danubeportal.com/. • To ensure the potential for future development: Extension of the database upstream, integration of River Information Services, integration into additional corridor-oriented systems like the Danube Fairway Information Services (FIS) portal.	
Background information	
Inland waterway marking includes the preparation of marking plans, establishing waterway marking systems and maintenance of these systems. In the Danube stretch covered by the marking database the continuous process of fairway marking (check of functionality and location of buoys) runs throughout the year in accorded intervals. The marking plans are adapted annually and mapped according to a clearly defined process. For common river stretches, Serbia established a joint annual marking plan with Croatia, while Romania and Serbia had separate marking plans. Bulgaria was also able to build up a good cooperation with neighbouring waterway authorities in the recent years, as corrections of position and repair works are performed in close cooperation with neighbouring waterway agencies.	
Description of activities	
Within the EU co-funded project NEWADA duo, a corridor-oriented fairway marking database was developed, harmonizing all separate marking plans and cooperation between only two countries	

G) CORRIDOR-ORIENTED FAIRWAY MARKING DATABASE	Danube Serbia, Croatia, Bulgaria, Romania

(see NEWADA DUO 2014e). The national authorities are still responsible for maintenance and development of the respective Danube stretches. All four countries, however, work on a harmonized marking plan and a cooperative fairway marking database. Each country supervises and updates the database, prepares marking plans and publishes data. Marking signs are installed and maintained by the crew in the field using a ship marking application for entry of all relevant data related to the marking signs. An office marking application enables online verification of the activities performed in the field. This application also contains internal data related to resources, inventory and costs of activities. Thus the workflow and management can be optimized.

Once verified, data from the office application is directly transmitted to the central marking application, which is open for the public. It offers insight into the real-time status of the whole marking system on the Danube river in the four respective countries. Data can be listed in tables or viewed on maps. It can be filtered as well. The application runs in English, Croatian, Serbian, Bulgarian and Romanian. The background map is an Inland ENC, which provides the potential for future extension of the system.

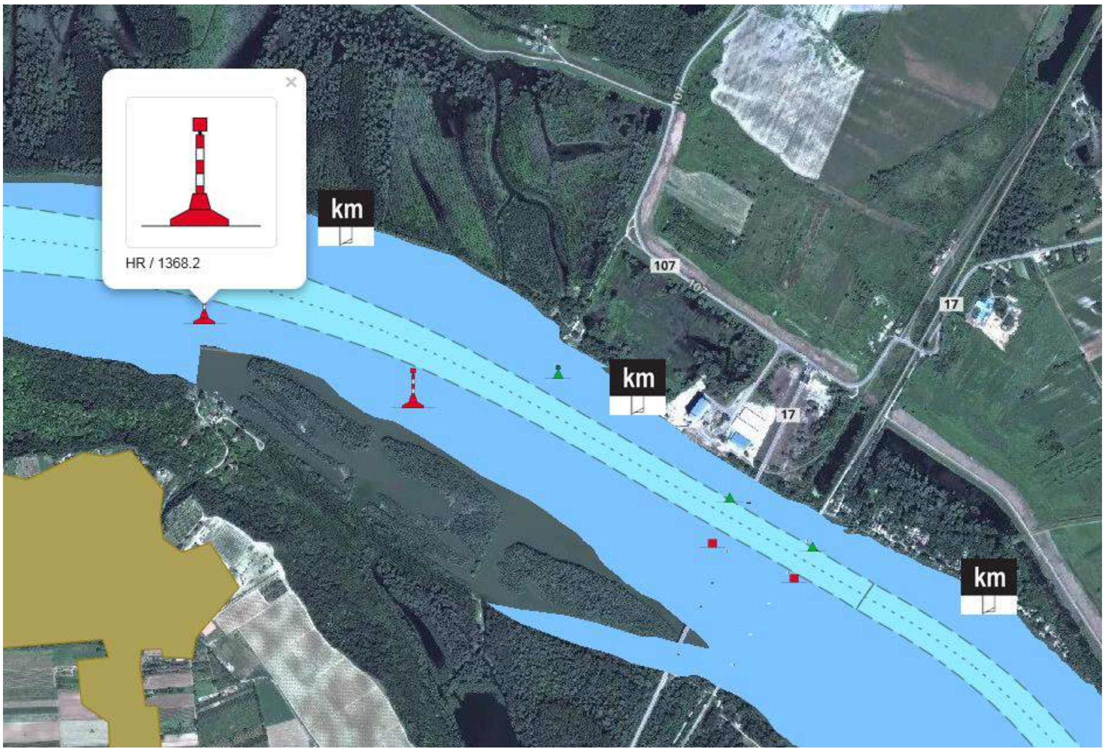

Figure 31: User interface of fairway marking database developed in the NEWADA duo project

Users and stakeholders

- The waterway authorities of Croatia, Serbia, Bulgaria and Romania operate the joint database and facilitate maintenance actions.
- Navigation authorities, skippers, forwarders, tourist navigation are beneficiaries of the

G) CORRIDOR-ORIENTED FAIRWAY MARKING DATABASE	Danube Serbia, Croatia, Bulgaria, Romania

maintenance of the marking systems.

Key success factors and innovative aspects

- Fairway signalization was harmonized on trans-national level.
- All marking signs, buoys and coastal signs are displayed via a single web-based interface. It permits to receive a fast overview and detailed information about the location of the signs.
- Each country is responsible for keeping the national data up to date. The cross-national database links the national databases through harmonized standards and interfaces.
- Coordinated updates happen on a regular basis. Backups make sure that data stays available also during exceptional situations like e.g. extreme weather events that might dislocate signs or other equipment.

Time frame and status

The database system was developed and implemented within the EU co-funded project NEWADA duo (2012–2014), which aimed at promoting the corridor-approach in waterway management along the Danube (www.newada-duo.eu). The system is fully functional right now. Further steps are envisaged in a follow-up project. The next steps include:

- Extension of the coverage to upstream Danube riparian countries,
- Further integration of dynamic marking data into the Danube Fairway Information Services portal (e.g. position adaptions of buoys based on GPS signals and automatic data transmission) and possibly into the Danube Waterway Maintenance and Management System (WMMS),
- Enable access via mobile application, and
- Automatic data processing and provision.

Lessons learned

- The commitment of all (Danube) riparian states to continue and further energize their cooperation is crucial for the future success of inland waterways in the Danube region.
- The harmonization of standards (e.g. marking signs, data standards) is one of the most critical elements in this process.
- Sufficient resources for acquisition and installation of software and user trainings are necessary. Proper user training needs to be offered. The operation of such a system needs to be secured after a project ends; it requires sufficient resources.

Requirements for implementation in other Member States

The process of establishing a database can easily be transferred to other waterway corridors, even if marking procedures and standards are different. Only the willingness to cooperate, to harmonize data and the availability of necessary resources need to be available.

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G) CORRIDOR-ORIENTED FAIRWAY MARKING DATABASE	Danube Serbia, Croatia, Bulgaria, Romania
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7.1.4 Monitoring of fairway-related infrastructure

River engineering structures for low water regulation, such as e.g. groynes or training walls, also require maintenance and renovation work. These hydraulic structures ensure safe navigation conditions at low water levels and protect the river banks from erosion (see Chapter 7.2.1 – engineering measures). It has to be ensured that e.g. groynes retain their function undamaged in order to continuously direct the water at low discharge into the main flow zone and thus fixing the position of the fairway. If e.g. a training wall in the concave bend of the river was damaged, helicoidal flow would erode the unprotected bank. The eroded material would eventually form a sand or gravel bar in the fairway downstream of the damaged site and thus endanger safe navigation. These maintenance measures of hydraulic structures are also a job of the national waterway authorities.

Monitoring of the state of river engineering structures built for low water regulation purposes can be part of a computer-assisted asset management system (see Chapter 7.2.2). Waterway asset management is a multi-disciplinary approach for the development, maintenance, rehabilitation and replacement of waterway assets based on a comprehensive life cycle costing approach (see HASELBAUER et al. 2014). The fundamental goal is to preserve and extend the service life and availability of all waterway assets in a sustainable and cost-efficient way. The comparison of possible measures regarding river engineering structures is always based on an evaluation of the current condition of these structures in combination with an estimate of costs and duration of measure impact. Consequently, the main modules of a computer-assisted asset management system may include condition assessment, condition evaluation, planning and optimisation of measures, culminating in an automatized programme of works and contract specifications.

Damage of river engineering structures primarily occurs during floods, its scale depends on the given extent of physical protection of these structures (e.g. loose rip-rap, ballast layer, pavement, etc.).

Condition assessment of the current condition of river training structures for low water regulation can be performed by one or more of the following methods (these can be used in combination in order to gain a more accurate picture of the current state of these structures, as measurement results may complement each other):

- Image flight: Air-based survey of length, width and height parameters on board of an airplane using laser scan technology,
- Land survey: Land-based survey of length, width and height parameters at low water levels,

- Hydrographic survey: Bathymetric survey of length, width and height parameters on board of a survey vessel using multi-beam sonar equipment at medium to high water levels.

The results of any of these survey methods are integrated in a database (asset or maintenance management system) and can subsequently be evaluated (condition evaluation). To this avail, damage classes can be defined which entail a different prioritization of and different costs for remediation measures (see Figure 32). Based on this input, the asset management system may automatically calculate an annual programme of works which includes a priority sequencing of measures, rough estimated costs (which will facilitate measure planning) and a condition prognosis.

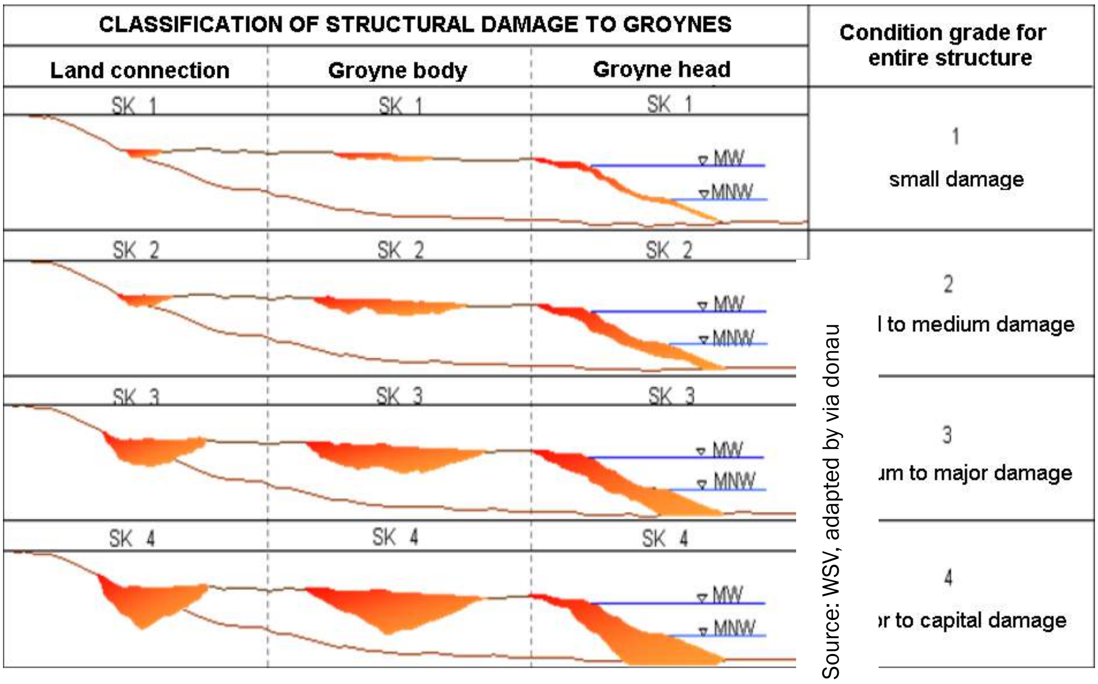

Figure 32: Classification of structural damage to groynes as applied to structures on the German stretch of the Elbe river

7.2 Planning measures

7.2.1 Choice of measures

In order to achieve fairway maintenance targets based on a fairway maintenance strategy, the optimum maintenance measure for a river stretch or a critical section is identified by taking the restricting factors into account – such as the available budget and personnel resources, available equipment (in-house or on the market), legal requirements, organisational framework, time frame for intervention, market situation or actors involved. These determining factors are usually very specific and individual for each maintenance measure. However, legal restrictions on European and national level influence the degrees of freedom for each measure.

With the aim to increase fairway availability, waterway authorities may choose between various possible measures, which are characterised by different costs, impact on availability, realisation time, duration of impact, resulting costs and environmental impact. Possible measures can be visualised in the form of a decision tree (see Figure 33). In order to identify the optimal measure for one section or location, all measures should be compared to the status quo as a "zero alternative", i.e. "no intervention" or "doing nothing", as well as to each other (NEWADA DUO 2014a).

Regarding the listed options and with the aim of implementing the most effective and efficient intervention, a combination of two or more measures may also be advisable. In addition, the numerals in the listing of the various available measure options in Figure 33 (decision tree) should not suggest that they are based on each other in a sequential manner. Options may be chosen in dependence of the desired effects of the planned intervention, i.e. the most effective and efficient fairway maintenance measure regarding measure costs, impact on availability, realisation time, duration of measure impact or environmental impact, among other things.

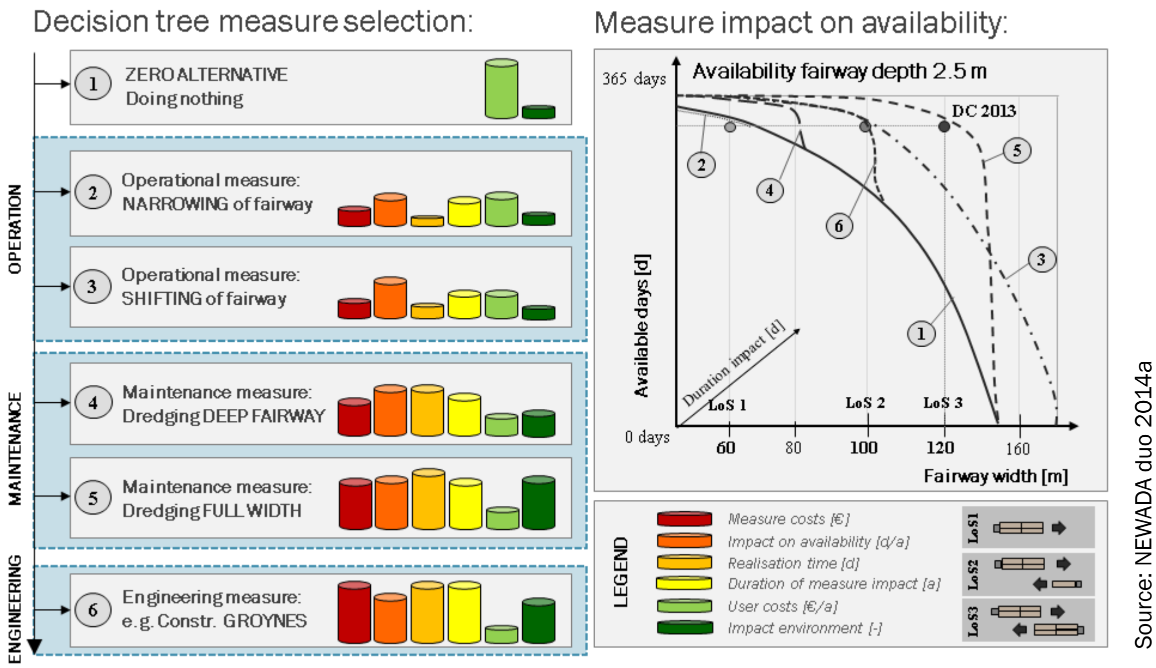

Figure 33: Decision tree for measure selection and resulting impact of measures on fairway availability

Zero alternative:

1. No intervention ("doing nothing")

Operational measures:

2. Narrowing of the fairway
3. Shifting of the fairway

Maintenance measures:

4. Dredging of a deep fairway channel
5. Dredging the full width of the fairway

Engineering measures:

6. E.g. construction of groynes or training walls

Operational measures

Operational measures (i.e. narrowing or shifting of the fairway) may be applied in order to improve the utilisation of the available fairway only in such cases where the target fairway depth is available on a sufficient number of days at least in one adequately wide area of the cross-sectional profile of the river. If the recommended fairway depth is not available on the entire width of the fairway, narrowing the fairway to those areas with sufficient water depths together with appropriate marking of the course of the fairway will allow a better utilisation of the physically existing availability (Measure 2). For typical wider river sections, which show a higher physical availability beyond the boundaries of the current fairway, the shifting of the course of the fairway may also be a cost-efficient option (Measure 3). However, a successful implementation of such operational measures requires periodic riverbed surveys, data processing and information of the users of the waterway (see e.g. Good Practice Example L, "Responsive fairway realignment and fairway information, p. 1182).

In some river stretches (e.g. on the Lower Danube or the Sea Scheldt) operational measures may be applied in order to improve the utilization of the available fairway. These measures are usually cheaper than maintenance dredging, can be implemented more quickly and hardly influence the environment. However, a sufficient number of days with adequate width and depth of the fairway is necessary for this approach.

The costs of marking activities primarily consist of time-dependent personnel costs (e.g. vessel crew) and distance-dependent operation cost of marking vessels (e.g. fuel) as well as amortization costs of marking equipment. The costs of operational measures are therefore mostly determined by the length of the marking section, but also through the monitoring interval with control and relocation of the position of floating marks. In general, they represent a less cost intensive intervention than dredging activities and if possible, their potential should be utilized.

Maintenance measures

In river sections without sufficient width and depth of the fairway only physical (i.e. maintenance) measures may lead to an increased availability of the fairway. Regarding decision tree measure selection, the term "maintenance" is used here in the narrower sense of physical alterations of waterway infrastructure by dredging (affecting riverbed morphology within the fairway). It excludes the maintenance (and repair) or river engineering structures like groynes or training walls. Maintenance dredging may include both sediment extraction out of the system and relocation of the sediment within the system, provided that these dredging measures aim at re-establishing the target fairway parameters (depth and width).

The least costly measure is to dredge a deep fairway channel on a minimum necessary width (e.g. "level of service 1") within the recommended width of the fairway in order to provide a continuous availability of a targeted fairway depth (Measure 4 in the decision tree of Figure 33). On river sections with a high traffic density and no budgetary or environmental restrictions, dredging the entire fairway width according to international recommendations may be considered as a favourable option (Measure 5 in the decision tree).

Based on an up-to-date riverbed survey (see Chapter 7.1.1), the sedimentation areas within the boundaries of the fairway are identified for those critical locations where the recommended fairway parameters or the fairway parameters for the minimum level of service will not be met without interventions or where the character of the critical location might endanger the safety and fluidity of navigation.

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Sediment management

There are possible synergies between relocation of sediment in the course of maintenance and rehabilitation activities and sediment management that is enacted in the course river basin management. Coordinating the planning of navigational dredging and reinsertion of material with River Basin Management Plans elaborated based on the demands of the Water Framework Directive, offers potential for synergies on both sides. An important first step would be to coordinate monitoring approaches for sediment transport.

There are no examples of a fully fledged integration of sediment management into river-basin management yet (Brils, 2012 in ISRBC, 2015). The International Sava River Basin Commission is working towards a sediment management system for the complete Sava river and published first guidelines on this issue ("Towards Practical Guidance for Sustainable Sediment Management using the Sava River Basin as a Showcase", ISRBC 2015).

The future Sava River Basin Management Plan is being developed by the Sava River countries and adopted by the Sava Commission. It will, among others, cover

- Sediment balance throughout the river system
- Evaluation of the sediment quantity and quality
- Measures to control erosion and sediment processes
- Designated areas for capital dredging
- Guidance for the sediment disposal, treatment and use

Engineering measures

On river stretches which show very dynamic river morphology the duration of the effects of dredging measures may be insufficient. This leads to the question of more sustainable measures. Measures with a long-term regulation effect are river training measures, which refer to structural measures taken to improve a river (i.e. to stabilize the fairway at desired parameters) and its banks. River engineering measures have multiple objectives, including e.g. enhancing flood protection, minimizing bank erosion or directing the flow of a river. In the majority of cases, however, the main objective is to improve navigation by maintaining certain fairway parameters in periods with low water levels (YOSSEF 2002). River engineering structures inter alia include groynes, training walls, or bottom sills.

Source: via donau/Zinner

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Figure 34: Groyne field on the free-flowing stretch of the Danube east of Vienna (Austria)

Groynes are structures that are usually built transversal or at an angle to the river's water flow. At lower water levels, they reduce the channel width and deflect the flow away from the riverbank. This deflection leads to higher water velocity and water levels in the fairway, thus improving navigation by increasing the fairway depth.

River training and maintenance measures show interrelations with each other. In general, planning and implementing structural river engineering measures takes longer than maintenance (e.g. dredging) or operational measures (e.g. relocation of fairway marks like buoys). Also, the first are more costly than the latter two. If e.g. dredging does not seem to improve the situation, river training might prove to be the right option (see decision tree for measure selection, Figure 33). Also upgrading river training may be beneficial. For example the lengthening of groynes can help to increase water levels in low water periods.

If engineering measures are chosen, then maintenance works do not become obsolete. Maintenance is especially needed during the execution of a river engineering project, but also afterwards. River training measures are constructed at critical river sections to enhance navigability during low discharges. Even though engineering measures have been implemented dredging is still required in critical spots with high sedimentation rates from time to time. If the sediment transport in a river section is discontinued (through e.g. impoundments) then riverbed degradation takes place. Groynes may accelerate this process on a local scale. Here, an upstream placement of dredged sediment may stabilize the riverbed and thus the water level (see e.g. Good Practice Example K, "Artificial bed load supply at Iffezheim", p. 111).

In order to also illustrate projects goying beyond the European waterway network, the following example illustrates engineering measures on American waterways.

Example: Bolters Bar, Upper Mississippi

This project of the US Army Corps of Engineers (USACE) showed how construction of river training measures can reduce dredging costs and at the same time be beneficial for multiple stakeholders (see GORDON 2004). Bolters Bar, a river reach of the Upper Mississippi river (see Figure 35), is heavily used by commercial navigation and serves as an important link between the Upper and Lower Mississippi river.

Due to high sedimentation, the USACE had to dredge many sections as often as twice a year, resulting in costs of US$ 500,000 in 2001 as well as waiting time for vessels. This was caused by the fact that – due to a three side channels – only half of the water was flowing through the main channel. Many standard engineering concepts could decrease the repetitive fairway dredging measures but were not accepted by environmental agencies and recreational interest groups. So, in 2002, the USACE implemented a (rather unusual) design taking the needs of all stakeholders and the costs into consideration: a longitudinal dike and four chevron structures were built.

Within the two years after the completion of the projects, the respective river section did not need any maintenance dredging measures. The structures actually lead to an increase of fairway depth and width. No downstream riverbed degradation occurred (see GORDON 2004). Also, chevrons proved to be beneficial for fauna and flora, esp. the aquatic life. The total project costs of US$ 1.5 million was amortized after three years as no further dredging was necessary (US ARMY CORPS OF ENGINEERS 2010).

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Figure 35: Innovative river engineering project at Bolters Bar in the Upper Mississippi, constructed in 2002 by the US Army Corps of Engineers

This project on Bolters Bar demonstrated how river training measures and maintenance works may complement each other – in this case the latter was not necessary at all any more. However, every case has to be assessed individually. A project such as Bolters Bar would most likely not work, e.g., on the upper stretch of the river Danube as the construction of chevrons requires a wide river cross section.

Special attention in this respect shall be given to *sediment traps* – a measure which might be described as an intermediary between maintenance (dredging) and river engineering. Sediment traps are troughs on the riverbed that collect downstream drifting sediments at a single location. This reduces maintenance dredging requirements downstream of the trap as sediments are not transported any more into critical areas. To ensure the efficiency of the sediment trap itself it has to be dredged periodically.

Example: Upper Sea Scheldt

In the Upper Sea Scheldt engineering/maintenance pilot projects are conducted at three sites. Their objective is to examine how dredging measures can be minimized (i.e. less volume and frequency) in areas that are subject to quick re-sedimentation processes. The first two sites are located at outer river bends with an eroded overdepth (see Figure 36). This overdepth will be filled with river sediment and then protected against erosion either with fascine mattresses or geotubes. This reduction of water depth will increase the flow velocity, which will prevent sedimentation in the inner curve.

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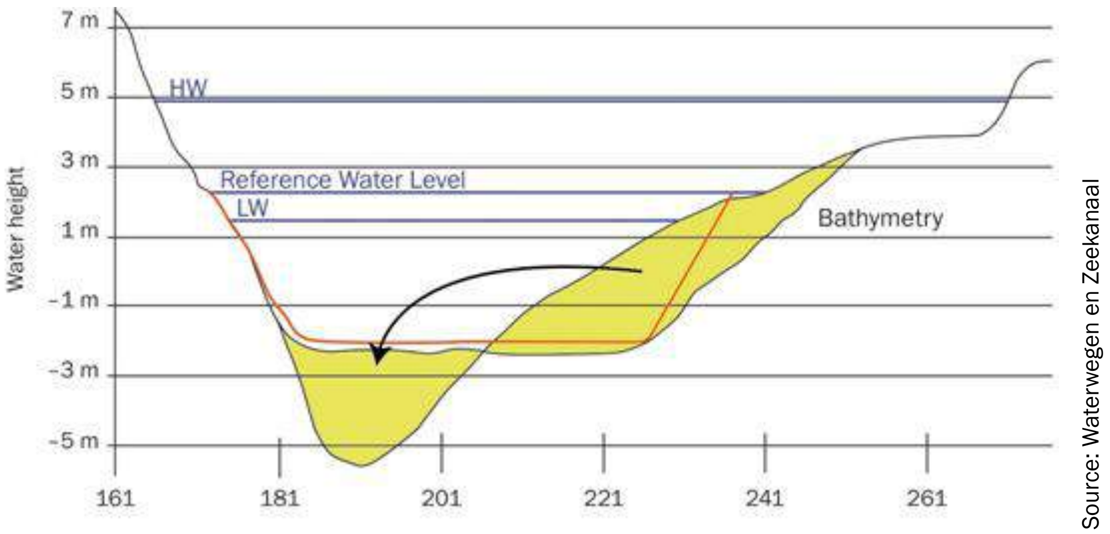

Figure 36: Cross-section of project area #1, Upper Sea Scheldt

The third project site is located at a bottom sill that is subject to regular sedimentation. Here the adjacent riverbank will be raised through sand supplementation (taken from the sill), leading to the establishment of shallow water areas and freshwater marches (see Figure 37). Similar to the first two sites, these measures lead to a narrowing of the river section, resulting in an increase in flow velocity, which, in turn, shall prevent the sedimentation process of the previously dredged bottom sill.

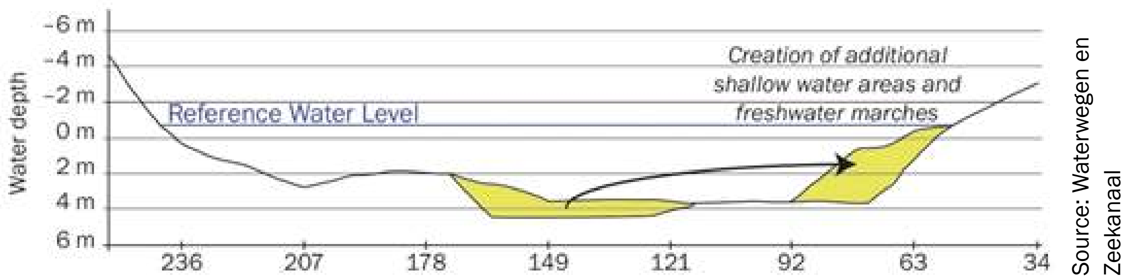

Figure 37: Planned measures at project site #3, Upper Sea Scheldt

No matter what measure or combination of measures are chosen, the objective to eliminate navigational bottlenecks stays the same. This will have a positive impact on transport costs for waterway users. At the same time the interests of the environment and all other stakeholders need to be considered. In the best case a "win-win" situation may be created.

Environmental permits

Regarding fairway maintenance dredging measures, official notifications or licences are needed from the competent national authorities as pertaining to water law, environmental law (including an impact evaluation with regard to Natura 2000 areas), navigation law and (in some regions) national park law. The authorities responsible for checking environmental issues also have to comply to the goals of the legislative instruments of the European Union, e.g. the Water Framework Directive

(WFD).The WFD requires Member States in Article 4.1(a) (i) to "implement the necessary measures to prevent deterioration of the status of all bodies of surface water" (EUROPEAN COMMISSION 2000).

Another goal is to protect, enhance, (and restore) these water bodies in order to attain the (i) good surface water status, or (ii) good ecological potential and good surface water chemical status. However, within the Directive, the term "deterioration of the status" of a body of surface water is not further defined. As regards sediment management, there are a number of references to sediment in the WFD, but all addressing chemical quality.

A court process between the Federal Republic of Germany and the German Federation for the Environment and Nature Conservation (Bund für Umwelt und Naturschutz Deutschland e.V.)- concerning dredging in the river Weser - led to a judgement of the European Court of Justice on 1 July 2015 concerning this matter (Case C–461/13).

The two main conclusions of the ECJ on the Weser dredging case are[18]:

1. Article 4.1(a) (i) to (iii) of the Water Framework Directive must be interpreted as meaning that the Member States are required – unless derogation is granted – to refuse authorization for a specific project if it may lead to a deterioration of the status of a body of surface water, or where it jeopardises the attainment of good surface water status, or of good ecological potential and good surface water chemical status by the date laid down by the Directive.

2. The term "deterioration of the status" of a body of surface water, as described in Article 4.1(a) (i), must be interpreted as meaning that a deterioration exists as soon as the status of at least one quality element, according to Annex V, deteriorates by one class – even if this deterioration does not lead to a deterioration in the classification of the respective body of surface water altogether. If a quality element according to Annex V is however already in the lowest class, any deterioration of that respective element constitutes a "deterioration of the status" of the body of surface water.

Although the fact which lead to the ECJ decision mainly concerned the development of the waterway (i.e. capital dredging in the navigation channel), some conclusions concerning fairway maintenance may be learned (first summary and preliminary analysis in relation to navigation by PIANC, see INLAND NAVIGATION EUROPE 2015):

- According to the wording of Article 4.1(a) (i), the Water Framework Directive has a binding status as the Member States "shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water" as determined in the river basin management plans (31).

- The prevention of deterioration and the achievement of the good status are two separate objectives of the WFD (40, 49) and appear to be on equal footing.

- Irrespective of long-term planning, any deterioration of the status of a waterbody must be prevented within the RBMP and Program of Measures (50). Member States are therefore required to refuse authorization for a project that may deteriorate the status of a waterbody or

[18] For more information, see the Weser press release: http://curia.europa.eu/jcms/upload/docs/application/pdf/2015-07/cp150074en.pdf

jeopardize the achievement of the good status (50-51), unless the following conditions (Article 4.7) are met:

(a) all practicable steps are taken to mitigate the adverse impact on the status of the body of water;

(b) the reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years;

(c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, and

(d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

- The term "deterioration" is not defined in the WFD (53). The ECJ concluded that a deterioration exists as soon as the status of at least one quality element, according to Annex V, deteriorates by one class (see above). Thus, the "one out all out" principle protects water bodies of highest and lowest ecological status class from deterioration (62-65, 69). Note that if a quality element according to Annex V is however already in the lowest class, any deterioration of that respective element constitutes a “deterioration of the status” of the body of surface water.
- If maintenance works have a significant impact on a quality element of a water body, the can only be implemented as an exemption according to the WFD, (see above and Good Practice Example J, "Instruction for the handling of dredged material of inland sediments (HABAB 2000))", p. 107.)

Preparing short-term maintenance measures (tendering)

In principle, permits (water law, environmental law, navigation law, etc.) have to be requested from the authorities for every single dredging measure in the river. An effectual notification always includes certain regulatory requirements as to how the dredging works in question have to be performed (e.g. defining specific months in which no dredging is allowed because of disturbance of fauna and flora, specific water levels above/below which dredging is forbidden, or restrictions on the amount of dredged material to be dumped in the river at once). In some cases, long- or medium-term notifications are issued by the authorities, which may cover dredging interventions over the period of several years, based on specific regulatory requirements for the approved dredging works. In this case, permits for single measure do not have to be obtained.

The procedures between the choice and the actual implementation of measures are crucial for their effectiveness. Long-time intervals and difficult procedures for procurement, eventual restrictions of available dredging equipment and further resources, a multiple number of parties that need to be involved and coordinated are all risks that have to be considered.

Concerning these things, the Manual focuses on the issue of procurement procedures (tendering). These procedures are regulated by two EU Directives[19], which are supplemented by national procurement laws. Contracts exceeding a certain threshold have to follow the procedures of the EU Procurement Directive, while national regulations also apply to contracts below this threshold.

Following thresholds are in force by 2015:

- EUR 5,186,000 for works contracts (e.g. dredging works),
- EUR 207,000 for service (e.g. riverbed surveys) and supplies contracts (e.g. equipment).

The procedures usually applied for the procurement of maintenance works are open procedures and framework agreements. As the market is already limited restricted procedures are not expedient. Negotiated procedures would cause efforts and expenses which are avoidable as the requested works can be specified in detail beforehand.

In most European countries general annual dredging activities are carried out by private contractors on the basis of framework agreements covering a time span of several years. Lead times for general dredging works depend on the extent of the work (scale of construction setup, availability of equipment) and can last from several weeks to months. In addition, some waterway administrations have their own dredging equipment available for emergency interventions, whereas other administrations lack such equipment completely. Especially the latter group is usually confronted with the results of a limited market of dredging companies, which may result in insufficient capability to perform necessary dredging activities and/or at high costs.

In 2015 via donau, the Austrian Waterway Company, who has to deal with a limited dredging market, came forward with a differentiated set of framework contracts for dredging services:

H) MULTIANNUAL FRAMEWORK CONTRACTS FOR DREDGING SERVICES	Danube Austria
Problem/topic	
Annual dredging interventions for the maintenance of the fairway of the Austrian Danube and other areas of the waterway that are under federal responsibility totally average about 400,000 to 500,000 m³ of sediment. As the Austrian Waterway Company (via donau) does not own their own dredging equipment these services have to be entirely contracted on the market. This entails a certain lead time for tendering.	
Objectives	
• To ensure a short lead time for the start of dredging work after a call: In the case that a framework contract is available with a contractor and that all legal notifications for the planned measure are on hand there shall be only maximum three weeks between the order of the service and the beginning of dredging works.	

[19] Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts. Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC has to be transposed until April 2016 into national law.

H) MULTIANNUAL FRAMEWORK CONTRACTS FOR DREDGING SERVICES	Danube Austria

- To ensure stability of prices during multiannual terms of contract: Specific maintenance dredging works, i.e. call-off orders, are implemented on the basis of fixed prices as specified in the framework contract. Nonetheless, a certain price spectrum is an integral part of these contracts, as the distance between the dredging and the placement site(s) may vary from call to call.
- To ensure reliability of performance due to delivery at call: In order to ensure the implementation of dredging measures in accordance with the terms of the contract, both the timely beginning of the works as well as the deadline for completion are penalized.

Background information

As the cross section of the Austrian Danube is rather narrow and the river stretch is to a high degree fixed by river engineering structures, the course of the fairway is normally not subject to change. The main nautical problem on the Austrian section of the Danube is created by sedimentation processes (predominantly gravel) within the boundaries of the fairway on the two free-flowing sections of the river. There, 36 locations are currently characterized as being "critical" for navigation. 19 of these locations show a high priority in terms of necessary maintenance interventions.

Description of activities

The objective was to cut down on lead times after EU-wide public tendering, and to achieve a stability of prices and performance. Therefore via donau set up multi-annual framework contracts for 50% of the annual dredging measures, including a response time of maximum three weeks between the time of order and the start of the maintenance works on site. Multi-annual framework contracts are set for the duration of three years with an option of prolongation for up to two additional years. The remaining 50% of all annual dredging works are individually tendered on the market if needed. This measure keeps the market open and counters tendencies of monopolization.

Users and stakeholders

- The Austrian Waterway Company (via donau) as consignor of dredging services.
- Private dredging/river engineering companies as contractors.
- Navigation and logistics companies as users of the waterway who depend on the good status of the waterway's infrastructure.

Key success factors and innovative aspects

- Precisely specified tenders for framework contracts set up for a defined river section and its characteristics, including dredging volumes, response times, prices and penalties.
- Optional prolongation of framework contracts for up to two years in case of satisfactory performance of contractor(s).
- 50% framework contracts and 50% individual tenders enables on the one hand a quick reaction in the face of detrimental sedimentation processes and on the other keeps enough

H) MULTIANNUAL FRAMEWORK CONTRACTS FOR DREDGING SERVICES	Danube Austria
competitors in the market in order to be able to tender services parallel and in addition to those covered by a framework contracts.	
Time frame and status	
Tenders have been assigned for the first time in spring/summer 2015. Multi-annual contracts with dredging/river engineering companies started in fall 2015 for the duration of three years (optional prolongation possible). Individual tenders may be assigned in case of need, e.g. after significant sedimentation due to floods.	
Lessons learned	
No lessons learned yet, as the framework contracts have just started; but two aspects from previous framework contracts for dredging services, which were accounted for in drafting the new contracts, shall be mentioned: • To split up the call for 50% of dredging services via framework contracts and for 50% via individual public tendering proved to be of value. • A differentiation as to the weighting of dredging services according to different waterway maintenance stretches is a direct result of the experiences made in the past, i.e. different amounts of dredging volumes for different stretches and for different dredged materials (gravel and fine sediment).	
Requirements for implementation in other Member States	
If a similar approach is taken in other Member States depends on local market conditions and on the availability of in-house dredging equipment of waterway administrations.	
Further information/contact	
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Outsourcing

In face of cutbacks in staff and availability of experts as well as lack of or overaged equipment at waterway administrations, the **outsourcing of specific aspects of fairway maintenance processes** to external service providers represents an option. Among the advantages of outsourcing are:

- Outsourcing supporting processes to service providers gives waterway administrations more time to concentrate on their core processes

- The contractor usually is a specialist in his field and disposes of specific equipment and long-time technical expertise,
- Certain responsibilities of waterway administrations may be shifted to the contractor who can usually plan risk-mitigation factors better as he is a specialist,
- Recruitment and operational costs can be minimized to a large extent, as outsourcing eludes the need to hire experts in-house.

Disadvantages of outsourcing may include non-delivery at appointed deadlines, sub-standard quality output, inappropriate categorization of responsibilities, lack of customer focus (the contractor may be catering to the needs of multiple organisations at a time), considerable time and effort needed by the waterway administration in preparing contracting documents, or lack of control concerning the processes in external service provision.

Before actually contracting an external service provider, it is advisable to specifically determine the importance of the tasks which are to be outsourced. In principle and with regard to the fairway maintenance cycle (see Chapter 7), the two **core processes of monitoring and execution** in waterway management may be outsourced. Monitoring refers to hydrographic riverbed surveying and water level measurements (hydrology), while execution relates to fairway dredging measures and adjustments of the course of the fairway (fairway marking by means of buoys, spears, etc.).

On the other hand, it has to be ensured that **essential resources and competences** (e.g. planning, analysis, quality control, coordination) in all steps of the fairway maintenance cycle stay in the hand of waterway administrations. Only then will they be able to conform to their responsibilities of public administration and to provide the targeted infrastructure parameters to the users of the waterway. It is necessary that they are able to independently act and make decisions on the basis of neutral and exact data gathered in-house. Skilled staff is an important asset in this respect, as they are capable to evaluate results and activities in order to guarantee independent decision-making. Contracts with service-providers need to comprise agreements on content and timing of information transmission to the waterway administration in order to enable a common picture of the current situation.

In the following, aspects of outsourcing with regard to the monitoring and execution steps in the fairway maintenance cycle are described.

Hydrographic riverbed surveying (monitoring): The general survey of entire river stretches in order to obtain a broad overview on the situation may be outsourced to specialised private companies. If different private companies on the market are contracted, it must be ensured that the quality of all measurements, especially regarding their accuracy as to altitude (z-axis) and positioning (x- and y-axis), is on a high standard and that the single measurements are comparable among each other. For waterway administrations, it is essential to have reliable survey results at hand which allow for mid- to long-term evaluations of the changes in the morphology of the riverbed based on comparable series of data. Regarding hydrographic riverbed surveys which aim at monitoring the success or quality of fairway maintenance dredging or fairway realignment interventions, i.e. riverbed surveys before and after dredging works (including potential intermediary surveys), these should be performed in-house with own equipment in order to be independent of private companies offering different qualities of performance. In this case, it is essential that measurements are taken without delay immediately before and after maintenance measures and that lead times are avoided, as morphological changes in the riverbed take place on a continuous basis.

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Water level measurements (monitoring): In many countries the water levels of surface and ground waters are monitored by federal or state hydro-meteorological services by means of gauging stations. Related information services for the public are mostly targeted at flood alerts and water level prognosis models are usually optimised for high water levels. By contrast, hydrological information on low water levels is essential for navigation and waterway authorities alike, as proper fairway maintenance mainly shows its effects at low water levels and is geared towards the corresponding reference water levels (e.g. Low Navigation and Regulation Level on the Danube, Equivalent Water Level on the Rhine or Reference Low Water Level on the Scheldt; cf. Chapter 7.1.2). It is thus consistent that waterway administrations maintain their own water gauges especially for the purposes of low water monitoring. Exact, consistent and gapless data on water levels are indispensable for hydrodynamic levelling, i.e. for calculating the slope of the water table especially at low water levels, which is needed for setting reference water levels on a specific river stretch.

Fairway dredging (execution): In general, fairway maintenance dredging works may be performed by private companies or a group of bidders on the basis of single or framework contracts. A prerequisite in this respect is that a sound quality management and monitoring system is applied by the principal, i.e. the waterway administration, which allows to ensure the desired effects of the works. Reliable and neutral site supervision is crucial. Services in this respect can be performed in-house or may be contracted on the market. Outsourcing contracts may specify separate prices for each maintenance intervantion. For reasons of assuring the safety and fluidity of traffic, it is advisable to hold an in-house dredging set available which enables quick intervention in cases of emergency.

The Flemish waterway administration, NV De Scheepvart, has own dredgers to solve urgent problems immediately. In Germany, the last excavator was sold in 2012; a new excavator is planned to be bought for the North Sea. At the Rhine, there are no framework contracts at the moment.

Fairway realignment (execution): Marking of the fairway: Parallel to the description of possible outsourcing of hydrographic services, the general, i.e. normally fixed part of fairway marking could be outsourced to a private company. As to the marking of critical sections, which may change rather quickly, marking of the fairway should be kept in-house in order to ascertain short reaction times.

In summing up the question of outsourcing, the waterway administrations agree that base competencies as described above need to be kept within the administration and outsourcing is no viable option.

Performance Contracting – Lessons learned at Waal River

On the Waal river, a tributary of the Rhine, the Dutch waterway administration Rijkswaterstaat outsourced maintenance dredging measures in 2012. A private dredging company received the acceptance of bid to conduct waterway maintenance activities until 2016. The main job is to dredge the 78 km long stretch of the waterway, whereby minimum fairway dimensions of 150 × 2.8 m must be guaranteed. In addition to the regular maintenance the contract also includes a fixed number of different activities, e.g. emergency services, breakdown services, or ice control.

The contract between the two parties is based on a new approach called performance contracting where the contractor has maximum freedom and flexibility as he can chose the working strategy himself (working method, tools used, planning, etc.). The payment is based on performance – in this case the desired state of infrastructure maintenance (targeted fairway parameters). From the perspective of the contracting authority a performance contract seems to be beneficial due to simpler project management, lower costs and more focus on the objective itself.

However, multiple challenges arose at the Waal. But at the same time valuable lessons could be learned. 750 groynes were lowered. This created an uncertainty in the quantity of material that would have to be processed annually. Therefore the tenderer could not accurately calculate his bid. Before the contract was signed, the authority informed the contractor that some areas of the river Waal were more eroded than beforehand expected and that the dredged material had to be reinserted primarily there. The first lesson learned is the importance that at the start of a project the contracting authority and the contractor have the same expectations and that all relevant information is communicated in a risk session before signing the agreement.

Another challenge arose concerning underground cables (phone lines, power supply lines) that cross the river. Neither all their locations and owners are known, nor if the cable is still in use. This resulted in a lot of extra work in regards to communication between the authority, the contractor and the cable owners. The next question that arose was who is responsible for the removal or relocation of the cables (usually, if in use, cables are inserted deeper into the sediment). Until 2015, no solution to this problem has been found. In future, such issues have to be dealt with before requesting for tender; and they have to be included in the contract.

Another issue occurred in 2012. Rijkswaterstaat found out that the contractor could not cope with the demanded performance in regards to bathymetric surveys (accuracy, frequency, and updating of "BOS Dredging" – the computer program in which all data of the Waal are recorded). Therefore the authority stopped all payments until the problem was solved. It became obvious that – before signing new contracts in the future – expectations and demands of both parties should be as clear as possible.

If other Member States wish to implement the same contracting method it is vital that available data is accurate, complete and available in the tendering phase of the project. Also, all parties have to be willing to cooperatively tackle challenges that might arise during the project. If performance contracts are used as a method to mitigate problems by handing over this task solely to the contractor (which is the character of such a contract), then the focus will shift to legal issues rather than finding operational solutions which optimal for river maintenance. About 90% of the arising problems are (and should be) within the realm of the contracting authority.

7.2.2 Computer-assisted waterway (asset) management tools

Some waterway administrations have IT systems at their disposal which support the detailed planning, execution and assessment of fairway maintenance measures. Depending on the targeted level of service for fairway parameters, the necessary width and depth of the dredging area can be determined and may be automatically displayed in a computer-assisted waterway maintenance management system as a suggested dredging polygon. In a further optional step, the manual optimization of the dredging measure (based on changes in the shape of the automatized dredging polygon and target depth) allows to account for individual local circumstances. The impact of the measure may be displayed by a backfilling rate curve, i.e. how long will it probably take for the excavated bed load to fill back into the dredging area.

These systems often also allow a rough estimation of construction costs of river engineering measures such as groynes based on the number and geometry of these structures. They deliver valuable data for long-term assessment of measures.

A detailed feasibility study for a multinational waterway maintenance management system (WMMS) for the Danube corridor was drafted in the EU co-funded project NEWADA duo by the Vienna

University of Technology (Institute of Transportation) in cooperation with the NEWADA duo project partners (Danube waterway management authorities) (see NEWADA DUO 2014a).

Among the possible components of a computer-assisted waterway management system are:

- Database and visualization: Storage and display of traffic infrastructure, including the fairway, riverbed surveying data, water gauging data, as well as markings/waterway signs and river engineering structures for low water regulation.
- Vessel draught and availability: Analysis of historical data and current state of possible draught and infrastructure availability in dependence of the development of river cross-profiles (river morphology) and water levels (discharge).
- Critical sections or locations: Current status and possible future development of critical (i.e. shallow and/or narrow) waterway sections or locations (such as fords and areas showing lateral sedimentation), including resulting fairway depths.
- Early warning system and fairway continuity: Alert system for critical developments in the fairway together with development tendencies as well as duration and priority with regard to fairway continuity.
- Database with measures and planning: Systematic input and analysis of completed as well as planning of new operational, maintenance and river engineering measures according to costs and effect duration.
- Monitoring and benchmarking: Analysis of effect of all processes related to waterway management in order to ensure continuity and quality of work.
- Process management and documentation: Implementation of work flows in the sense of process management as well as documentation with the goal to retain knowledge and practical experience.

WAMS ("Wasserstraßen Management System") is a computer-assisted waterway management system in use at via donau, the Austrian waterway management company, that comprises many of the above-mentioned components. This Good Practice Example shall therefore be presented in detail:

I) DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER-ASSISTED WATERWAY MANAGEMENT SYSTEM	Danube Austria
Problem/topic	
The necessity of effective and efficient utilization of resources in waterway management is of increasing importance in the light of stagnating economic development and raised requirements regarding commerce, navigation, administration and ecology. Due to these, the case-by-case and empirically based management of waterways has reached its limits.	
Objectives	
To develop a comprehensive asset management system for waterway management, including a step-by-step implementation as a software tool (WAMS – Wasserstraßen Management System).	

I) DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER-ASSISTED WATERWAY MANAGEMENT SYSTEM	Danube Austria

Background information

Inland waterways in Europe face a resource patchwork, low availability and effectiveness of investments leading to a declining importance compared to other modes of transport. To overcome these setbacks the presented waterway asset management approach aims at an increased availability of fairway widths and depths in days per year. Based on periodic riverbed surveys, current water levels and discharge the impact of maintenance and river engineering works on the availability of fairway widths and depths can be analysed. Any resulting increase in availability on a transport route leads to a decrease in transport costs that are considered as a benefit of the implemented measures. Innovative alert systems based on an empirically derived behaviour of critical bottlenecks allow preventive measures and lead to real-time availability of information for the transport industry.

The approach enables an optimization regarding individual measures on river sections as well as of investment strategies for constrained budgets, recommended fairway conditions or total costs of waterway agencies and the transport industry.

Description of activities

The components of an analytical asset management cycle are the backbone for the implemented modules of the developed software WAMS:

- Collection of assets: Base model for fairway (different levels of service, various combinations of width and depth), water levels, hydrographic riverbed surveys (cross profiles, single- and multi-beam surveys) and waterway sections (chainage), including waterway signs and marking, and subsequent display of interactive map (data on water levels and hydrographic riverbed surveys are imported into the system on a daily basis).
- Assessment and prognosis: Availability of waterway sections and transport route (fairway parameters, continuous availability of the fairway) can be calculated for cross-profiles or for specific river sections.
- Objective and risks, strategy and measures: Overview on measures in waterway management (decision tree) with different target parameters (levels of service), effect-focused planning of measures (mainly dredging) (any planned dredging measure is documented in the system, including definition of dredging and placement areas, calculation of cubature and costs).
- Allocation of resources, implementation and monitoring, quantification of results: Prioritisation of dredging measures based on programme of measures, implementation of maintenance measures and assessment of costs and results (measure effect, backfilling rates).
- Control and feedback: Display of available fairway depths in dependence of water levels, difference maps with erosion and sedimentation patterns, analysis of development for sediment volumes, availability of fairway parameters for specific waterway sections, etc.

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I) DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER-ASSISTED WATERWAY MANAGEMENT SYSTEM	Danube
	Austria

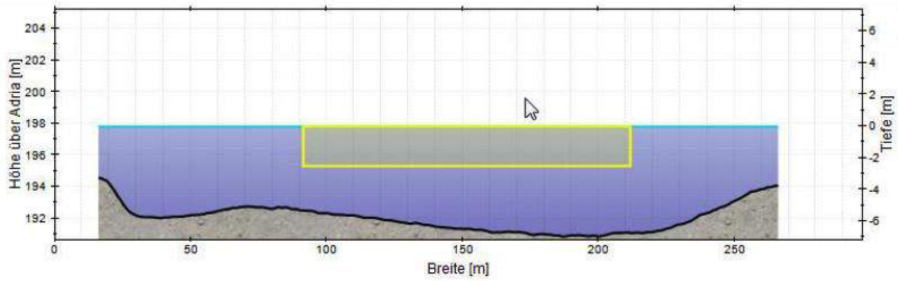

Figure 38: View of cross profile with fairway parameters (yellow rectangle) and water level information (blue line)

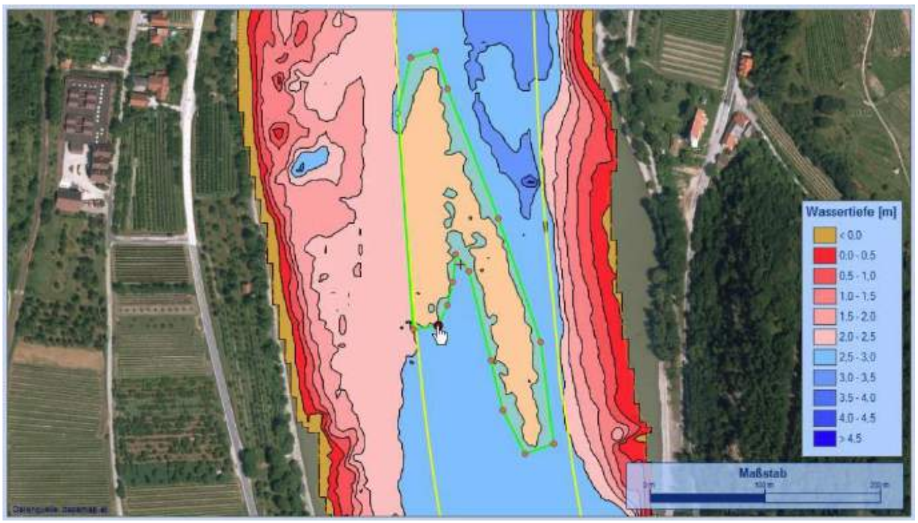

Figure 39: Display of dredging polygon with automatized calculation of cubature

Users and stakeholders

- WAMS development and implementation was achieved in a research project in cooperation of the Vienna University of Technology (Institute of Transportation) and the Austrian Waterway Management Company (via donau).
- Users are staff in waterway management organizations or authorities that are responsible for waterway management (fairway maintenance and marking, river engineering).

Key success factors and innovative aspects

- Availability, quality and input of basis data (riverbed surveys, water level information, etc.).
- Automatized monitoring and assessment of fairway maintenance measures.
- Automatized calculation of fairway availability and effect of measures.
- Different scenarios for fairway parameters (levels of service).

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I) DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER-ASSISTED WATERWAY MANAGEMENT SYSTEM	Danube Austria

Time frame and status

The project started in November 2012 and lasted until April 2015. Since then the software has been in operation at via donau. A subsequent project was started in autumn 2015 and will last until 2020. It shall integrate modules related to river engineering structures (asset management system aspects with regard to low water regulation), sediment management (aspects fairway maintenance dredging which help to mitigate riverbed degradation) and traffic management (evaluation of AIS vessel tracks for optimising waterway maintenance measures).

Lessons learned

- It is possible to provide a computer-assisted model for waterway management (especially fairway maintenance) on the basis of a decision tree and a program of measures.
- The necessity of an extension of the software was realized during the implementation phase. The following modules/extensions are planned: sediment management, cadastre of river engineering structures for low water regulation and interplay of these structures with dredging measures, information management and optimization of interfaces (inclusion of AIS vessel tracks, synchronization with available databases, e.g. on fairway signs and marks, on berthing places), streamlining with in-house process management, etc.

Requirements for implementation in other Member States

In the course of the NEWADA duo project, the Vienna University of Technology conducted a feasibility study on the development and implementation of a Waterway Maintenance Management System (WMMS) for the entire Danube waterway (NEWADA DUO 2014a). The identified requirements may also be transferred to other European waterway corridors:

- Harmonized database with uniform standards e.g. regarding water levels at reference water gauges, riverbed surveys and course of the fairway (fairway marking),
- Automatized assessment of results regarding measure implementation, costs and impact on fairway availability,
- Harmonization of investment strategies and implementation of measures in most critical bottlenecks are essential for continuous fairway availability,
- Compact and accessible information on fairway availability, nautical bottlenecks and other relevant information for the entire length of a waterway shall be available in one information portal or website.

Further information/contact

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7.3 Executing measures

The physical execution of the required fairway maintenance activities is the core of the maintenance cycle and the main task of waterway administrations. This process of fairway maintenance dredging and fairway relocation shall be thoroughly described.

7.3.1 Fairway maintenance dredging

As specified in Chapter 7.1.1, hydrographic riverbed surveys are conducted on a regular basis. Also observations made during fairway marking operations (monitoring and repair of floating marks) or notifications from other authorities, especially the navigation authority and its operational units (e.g. navigation surveillance or navigation police), may trigger additional surveys. The latest results of these bathymetric surveys are the start of fairway maintenance dredging interventions.

Dredging works are initiated in cases where the recommended fairway parameters for a certain level of service will not be met without interventions or where the critical location might endanger navigation safety and traffic fluidity. There are also other types of dredging activities in rivers, which are not directed at establishing fairway parameters and are thus not relevant for fairway maintenance. Consequently, they are not in the focus of this Manual. These may include works to establish certain water levels for the purposes of flood control, to create certain ecologically valuable zones near riverbanks (protection of wave wash from navigation), to win sediment (gravel, sand, etc.) for the construction industry or other commercial purposes or to positively influence the sediment balance of a river.

Fairway maintenance dredging works should be performed on the basis of a prioritisation of critical locations following the principle of establishing the continuity of the fairway (see Chapter 6.1.1). In common border sections of a waterway, the members of the respective cross-border waters commission have to be notified in due time about the planned intervention.

Ideally, the execution of fairway maintenance dredging works should be modelled as a core process in every waterway authority, as it is one of the core tasks of a traffic infrastructure operating body. Such a core process may include the following steps:

1. Collect functional requirements: Strategic in-house guidelines and targets which pertain to fairway maintenance are extracted from the relevant management and core processes of the authority (strategy, goals, water supervision, waterway management).

2. Analyse the current state of the fairway on the basis of hydrographic riverbed surveys, including river engineering structures for low-water regulation (input: characteristic water levels, catalogue of critical locations, results of bathymetric riverbed surveys, development of water levels; output: condition analysis of critical locations and of low-water regulation structures).

3. Draft a concept of measures: Identification of location, sediment type and cubature (m^3) necessary to be dredged as well as location of site where dredged material shall be dumped back into the river (input: budget, current status analysis; output: concept of dredging measures).

4. Prepare and execute annual briefing meeting for dredging works: The aim of this meeting is to attain consensus with the navigation authority as to the necessary measures for the proactive maintenance of the fairway and to set out in writing a prioritisation of fairway dredging

interventions (input: budget, current status analysis, hydrographic riverbed surveys; output: prioritisation of dredging measures, meeting minutes of annual briefing meeting).

5. Perform context management: Communication with waterway users, including in-time notification of dredging measures to the navigation authority (to be later published as Notices to Skippers), fishermen and operators of berths (input: details of planned measures; output: specific measures for context management).

6. Check official legal notifications for dredging measures: There are mainly two possibilities, i.e. valid ("permanent") official notifications for the planned dredging measure are available (pertaining to water, environmental, navigation and national park law) or an application has to be filed with the competent authorities for such notifications for a single dredging measure. In the second case, all relevant documents for the administrative procedure have to be compiled in house prior to application. Documents should be prepared in cooperation with in-house or external lawyers (input: planned measure, catalogue of prioritization; output: application documents for attaining legal notifications).

7. Carry out a notification process for attaining permits pertaining to water, environmental, navigation and national park law (input: application documents; output: valid legal notification for planned measure).

8. Check if a framework contract is available: If the planned dredging measure shall be performed by a private company with which the waterway authority has a valid framework contract, then the call-off of the measure has to be prepared. In all other cases, a tender procedure will have to be initiated (input: valid legal notification for planned measure; output: call-off of measure for framework contracts).

9. Carry out tendering procedure: If there is no framework contract available, a tendering procedure has to be conducted for every dredging measure (input: legal notifications, tender documentation; output: contract with seller for performing the measure).

10. Perform hydrographic riverbed measurement for dredging and placement sites: Prior to a fairway maintenance dredging measure, the critical location to be dredged as well as the area in which the dredged material shall be deposited into the river will have to be thoroughly surveyed (input: demand not for riverbed surveying, output: surveying results).

11. Carry out briefing for the beginning of the works: A meeting is scheduled with the contractor in which the details for the imminent dredging measure are finalised. Usually the navigation authority is also present at the meeting (input: surveying results, dredging contract, including the general and specific articles of agreement; output: signed meeting minutes of briefing). Details include: area and chainage (river-km) of the dredging and the placement site(s), target depth for dredging site, date of beginning and end of works, daily working hours, equipment deployed, responsibility to display navigational signs, relevant water gauge with reference water level and miscellaneous issues.

12. Perform dredging measure and (ecological and local/technical) site supervision: If legal or ecological issues occur during the fairway maintenance dredging measure, they have to be clarified in cooperation with involved lawyers and ecologists (input: contract for dredging measure and surveying results prior to measure; output: partial financial statement of the contractor).

13. Perform hydrographic survey during or after dredging measure: Generally, a hydrographic riverbed survey is to be performed after the end of the dredging measure for the purpose of quality assurance and settlement of accounts. The contractor therefore has to notify the waterway authority in due time about the estimated end of the measure. For dredging measures with a longer duration, an additional hydrographic survey can be performed during the measure (input: hydrographic survey order form; output: surveying results).

14. Control service level of accomplished measure (deficiency management): The daily reports drafted by the (ecological and local) site supervision as well as the final hydrography survey of both the dredging and the dumping sites are analysed. In addition, information necessary for in-house performance indicators are collected (input: dredging contract, daily reports of site supervision, surveying results prior, during and after measure; output: approved reports of site supervision, if applicable: list of deficiencies).

15. Order rectification works (in case of necessity): Has the contractor not achieved the agreed quality of the measure, finishing work has to be performed on the basis of a list of deficiencies (input: list of deficiencies, final hydrographic riverbed survey for dredging and dumping sites; output: final financial settlement).

16. Document achievement of objectives and performance indicators: The final financial settlement by the contractor is verified and the sum is authorised for payment. Performance indicators are calculated on the basis of final input data (input: financial settlement by contractor, daily reports by site supervision; output: approved final financial settlement, performance indicators).

Source: via donau

Figure 40: Dredging pontoon with visual signals (floating equipment at work, protection against wash, fairway clear on one side) and hydraulic crane together with hopper barge for transporting dredged sediment

As to the duration of a fairway maintenance dredging measure, a distinction must be made between the lead time before the beginning of works needed for contracting and the duration of works themselves. In case of contracting for a single dredging measure (i.e. no framework contract with a

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specific contractor or contractor group at hand), the tendering process takes some weeks, and – depending on the result of the tendering – some additional weeks will have to be calculated between acceptance of the bid and the beginning of works. The expected performance of fairway maintenance dredging may be measured in cubature (m^3) per week. This value is dependent on the kind of sediment to be dredged, the equipment used for dredging, the characteristics of the dredging area (e.g. dimension of the cross section, inflow of bed load, water current velocity etc.) and other aspects. The usual duration of a dredging measure (i.e. the operational works in the field) ranges between one day or a few days up to several weeks or even months. Dredging measures might be suspect to interruption due to high or very low water levels, ice formation in the winter months, technical failure, accidents, etc.

Achieving a balance between the need to dredge and adequate **environmental protection** can be a challenge. But in many cases measures to achieve the needed depth, width, and clearance of the fairway can be designed in such a way as to minimise the impacts on important waterway functions or to even restore ecological functions.

In the course of attaining legal permission for dredging activities, the various competent authorities consider user interests and usage aspects. The authorities usually involve official legal experts in judging the different effects of dredging on other uses of waterways (e.g. fishery, ecology, recreation, nature reserve, drinking water, etc.). Thereto related and site-specific restrictions are usually imposed by the competent authorities regarding the performance of maintenance dredging works.

The respective legal regulations in each country offer a certain bandwidth in which the waterway administrations may define and continuously improve an integrated management approach. The German Waterways and Shipping Administration (WSV) improved dredging measures by establishing an instruction for the handling of dredged material of inland sediments ("HABAB 2000"). It gives detailed information concerning this matter and also concerning possible contamination. Also, it advises in terms of economic viability and ecological requirements. This Good Practice Example shall be introduced on the following pages:

J) INSTRUCTION FOR THE HANDLING OF DREDGED MATERIAL OF INLAND SEDIMENTS (HABAB 2000)	All federal inland waterways Germany
Problem/topic	
Material dredged during development and maintenance works in inland waterways can be contaminated, often exceeding geogenic or regional threshold values. Henceforth, a catalogue of criteria for the assessment and handling of dredged material needs to be provided.	
Objectives	
• To advise in terms of economic viability versus ecological requirements. • To reduce costs of dredging measures and facilitate temporal savings.	
Background information	
The "Instruction for the Handling of Dredged Material of Inland Sediments" (HABAB) is a German document displaying the legal differences between waterbody maintenance[20] and development:	

[20] The term "maintenance" in this respect is related solely to the riverbed and riverbanks.

J) INSTRUCTION FOR THE HANDLING OF DREDGED MATERIAL OF INLAND SEDIMENTS (HABAB 2000)	All federal inland waterways Germany

- Maintenance: To facilitate necessary maintenance works, no legal permits are needed if the project promoter can declare his actions as maintenance works in accordance to German law. Maintenance works have no severe impacts on water resources and environmental protection and usually do not alter the character and conditions of the river stretch or project area. However, legal permits are necessary on behalf of nature protection (but no EIA has to be performed).
- Development: When it comes to waterbody development, planning procedures need to be endorsed by the plan approval authority. Waterbody development in accordance to German law are measures and actions undertaken to restructure an inland waterway, an inland waterway crossing, one or both banks, and that affect the inland waterway as a transport route.

Handling of dredged material – as a part of maintenance – is often combined with chemical and physical examinations. The condition of the excavated alluvial sediment henceforth determines its further usage. It can be either relocated, disposed, stored temporally, treated or placed for good (e.g. in landscaping or recultivation). In this respect project promoters need to consider the following regulations and policy frameworks: Federal Act for the Protection of Nature, FFH Directive, Birds Directive, Environmental Impact Assessment Act, Waste Water Act, Waste Water Charges Act.

Description of activities

The most recently updated HABAB 2000 outlines the most important steps for the successful handling of dredged material. These include the following aspects:

Processes and procedures: Prior to technical planning (e.g. dredging equipment, transport systems, recycling and treatment), several project aspects need to be taken into account:

- Assessment of the quality and quantity of dredged materials,
- Examination of different deposition sites and cost analyses,
- Tackled laws and needed permissions,
- Editing of comprehensible documents and notification of concerned parties,
- Choice of a feasible alternative and, if necessary,
- Establish evidence for the site of intervention covering all project phases,
- Prepare operation plans and control plans for the economic implementation.

In regards to tendering, authorities published an instruction report on "Tendering in connection to the extraction and assessment of soil, suspended load and water sampling as well as inventorying of riverbed fauna" (BUNDESANSTALT FÜR GEWÄSSERKUNDE 1994).

Assessment of dredged material: How to dispose dredged material is a question of quality and quantity of the excavated sediment. It must be assessed in respect to its physical, sedimentological, chemical, biochemical and eco-toxicological character. Maintenance works, in contrary to development works, do not require sediment assessment.

J) INSTRUCTION FOR THE HANDLING OF DREDGED MATERIAL OF INLAND SEDIMENTS (HABAB 2000)

All federal inland waterways

Germany

If material shall be deposited, the following tests have to be conducted:

- Physical, sedimentological and morphological examinations,
- Pollution tests,
- Faunal and floral examinations in the project area,
- Biochemical and eco-toxicological examinations.

So far, there are no comprising methods to assess the impacts of sediment deposition in surface water bodies. The following principles should therefore be taken into account:

- Physical-sedimentological criteria:
  - An adequate granulometry of material shall be used,
- Hydro-morphological criteria:
  - Deposition may not affect the natural sediment regime of the water body,
  - Deposition must not lead to constipation of autochthonous riverbeds and/or bank sediments.

Users and stakeholders

- The revised German Water Resources Act extended the responsibilities of the German Waterways and Shipping Administration (WSV) towards environmental objectives in 2010.
- Environmental experts and stakeholders were additional key contributors to the text.

Key success factors and innovative aspects

- HABAB 2000 provides detailed instructions on the handling of dredged material and takes the possible contamination of sediment into account.
- During its introduction in 2000, procedures and benchmarks were agreed upon and standardised on national level.

Time frame and status

The HABAB 2000 is the revision of the HABAB document from 1997. The 1997 version is an updated version of the publication "Application of the guidelines concerning dredged material of the Oslo and the Helsinki Convention in the Federal Waterways and Shipping Administration" (HABAK-WSV) of 1992.

An extended version of the HABAB 2000 is envisaged and will deliver instructions for the handling of dredged material not only for inland waterway authorities, such as the WSV, but for the public sector as well (federal and national level). It shall also contain instructions on the handling of maritime sediments in coastal areas based on the "Agreement on the Handling of Dredged Material in Coastal Areas" (GÜBAK 2009). The update of HABAB is challenging also due to the further evolvment and raising complexity of environmental legislation.

J) INSTRUCTION FOR THE HANDLING OF DREDGED MATERIAL OF INLAND SEDIMENTS (HABAB 2000)	All federal inland waterways Germany
Lessons learned	
• It is vital to illustrate the legal framework conditions and to show how dredged material can be successfully handled. • It is proven that a consistent standard for all German inland waterways is beneficial.	
Requirements for implementation in other Member States	
The basic principles of the HABAB may be transferred to other countries and regions. The specific proceeding however needs to be adapted to the local physical, sedimentological and hydromorphologic criteria and respect the legal framework and its specific limit values.	
Further information/contact	
Federal Ministry of Transport and Digital Infrastructure (BMVI) P.O. Box 200100, 53170 Bonn, Germany	

Every dredging measure is part of **sediment management**, particularly with regard to the removal of bed load sedimentation at nautically critical locations. As to the environmental effects of fairway maintenance dredging, the distance between the dredging site and the placement site where sediment is reinserted into the river as well as the location of the latter is of importance.

In free-flowing sections of natural rivers in which riverbed degradation occurs due to reduced supply of sediments because of barrages, weirs or hydropower plants located upstream of the specific section, it is of importance to reduce the removal of sediments from the section in order to mitigate riverbed degradation. This is in line with the provisions of the EU's Water Framework Directive (WFD) to prevent further deterioration of rivers and to protect and enhance their aquatic ecosystem status. As the removal of bed load from rivers is usually considered as a further deterioration of waters, material excavated in the course of fairway maintenance measures should be reinserted into the system. This should be done in the same river section. In particular when the material is inserted upstream, longer distances between the dredging site and the placement site are more positive for sediment balance in the respective river stretch showing degradation, as the bed load is kept in the system for a longer time and at a longer distance.

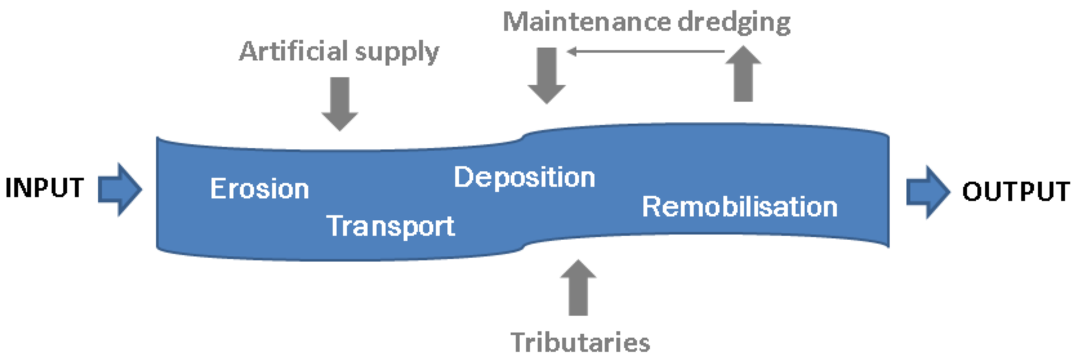
This procedure will only yield the desired effects, i.e. mitigating riverbed degradation, for sediment with a specific minimum grain diameter (e.g. gravel or sand) which is mobile and will be transported further downstream as bed load. Coarse particles of sediment (gravel, coarse and medium sand) move along the riverbed as bed load, while finer fractions (fine sand, silt and clay) are suspended in water and move as suspended load. A portion of suspended sediment is in permanent exchange with the riverbed material and takes part in morphological processes (bed-material load), the finest particles pass by without any interaction with the bottom of the river (wash-load).

With reference to KLASZ 2015 the amount of bed load deficit compensated by dredged material which is reinserted upstream of the dredging site can be calculated with a simple formula (see Figure 41). Here, the amount of dredged material (m^3 per week/month/year) is multiplied by the transport distance upstream (km) and divided by the length of the section in which riverbed erosion occurs (km). The result is the amount of compensated bed load (m^3 per week/month/year).

$$\textit{compensated bed load amount } [m^3] = \frac{\textit{dredged material } [m^3] * \textit{transport distance upstream } [km]}{\textit{length of section with riverbed erosion } [km]}$$

Figure 41: Formula for bed load equivalence (Source: KLASZ 2015: 75)

Apart from local sediment management in the course of specific fairway maintenance dredging interventions, mitigation of riverbed degradation is also undertaken at a larger scale, e.g. by means of artificial bed load supply to river sections which are characterised by riverbed degradation. Figure 42 provides a schematic overview of processes which have an influence on the bed load regime of a river. The fluvial processes of erosion, transport, deposition and remobilisation which affect bed load balance are dependent on the erosion resistance of the riverbed, the energy gradient and shear stress, which are again influenced, inter alia, by the amount of discharge, the slope of the river, sediment type and density and the specific morphologic character of the cross section.



Source: via donau, based on Habersack 2011

Figure 42: Schematic diagram of processes influencing the bed load regime of rivers

A successful example for good project planning and execution in positively influencing bed load regime and compensating for sediment deficitis the "Artificial Bed Load Supply at Iffezheim" on the river Rhine in Germany. It serves as a Good Practice Example also in terms of multi-disciplinary approaches, as the project targets the objective in a corridor-orientated manner and uses integrated management to reach its goals.

K) ARTIFICIAL BED LOAD SUPPLY AT IFFEZHEIM

Rhine

Germany, France

Problem/topic

The German Rhine between km 336.0 and 338.0 is heavily affected by riverbed erosion through a sediment deficit caused by a series of hydropower plants upstream of the town of Iffezheim. From Iffezheim downstream the rest of the Rhine is free-flowing but insufficiently supplied by sediments from areas upstream of the barrages.

Continued erosion may result in a narrowed fairway, reducing the possible payload of vessels. Furthermore, operational functionalities of adjacent infrastructural constructions like locks,

K) ARTIFICIAL BED LOAD SUPPLY AT IFFEZHEIM	Rhine Germany, France

bridges, ports and hydraulic structures might be negatively influenced too. A main risk also lies within potential environmental damages, e.g. due to negative influence on groundwater regimes.

Objectives

- To restore water levels and to stabilize them at the level of 1978 before the hydropower plant Iffezheim was built. France and Germany committed themselves to combat riverbed degradation without building a new barrage.
- To prevent a water level drop by more than 50 cm relative to the Equivalent Water Level (EWL, GIW) at the gauge of Iffezheim. Otherwise, a new barrage would have to be built.
- To ensure a navigable depth of 2.10 m below the EWL (1.70 m until June 1988) over the entire fairway width, with a safety margin of 40 cm below this depth.

Background information

Over the last 150 years the Upper Rhine has been rectified, regulated and partly developed for hydropower generation. Moreover, the construction of impoundments on the High and the Upper Rhine intensified erosion of the riverbed downstream by cutting off the supply of bed load material. Enforced by the worsening situation downstream, nine impoundments were completed in succession between 1952 and 1977, on average one in three years. Germany and France eventually committed themselves to combat the erosion at its source or by means of alternative solutions in a contract set up in 1969.

The controlled supply of bed material prevents new impoundments downstream of Iffezheim as well as long-term damage in water resource management. Moreover, controlled bed load supply is one of the few processes that can stop riverbed degradation without damaging the environment.

The German Waterways and Shipping Administration (WSV) and Voies Navigables de France (VNF) signed an agreement clarifying issues related to the safety of navigation, liability and cost sharing. The Central Commission for Navigation on the River Rhine (CCNR) approved the approach.

Description of activities

In 1975 field experiments with bed load supply were started as water levels at the gauge of Iffezheim began to decrease steadily and artificial armouring was not considered a viable option. The waterway authority started to artificially supply the eroding riverbed with bed load – a sand-gravel mixture with a granulometry corresponding to the natural bed material in grain size, grain size distribution and shape as far as possible. The positive results of the field tests led to a German-French agreement in 1982, which deferred the construction of a new impoundment and approved the method of artificial bed load supply. At the beginning of the measures the lowering of the EWL increased depth requirements. The lengthening of groynes downstream the placement site led to a further decrease of water levels. Additionally, quantities of dumped material were hardly related to the sediment regime of the Rhine.

Consequently, in 1995 the water levels at gauge Iffezheim displayed a decrease of 44 cm compared to water levels of 1978 (see Figure 44). Eventually the waterway authority started to supply material in correlation to the discharge at Iffezheim, as exceeding mean discharge (1,250 m^3/s) leads to intensified erosion and thus to an increased need for bed load supply (see Figure

K) ARTIFICIAL BED LOAD SUPPLY AT IFFEZHEIM

Rhine

Germany, France

43). In combination with river training works (extension of groynes and partial riverbed stabilization with coarse particles), an approximation to the reference water levels of 1978 was achieved and even resulted in a water level increase in the last years.

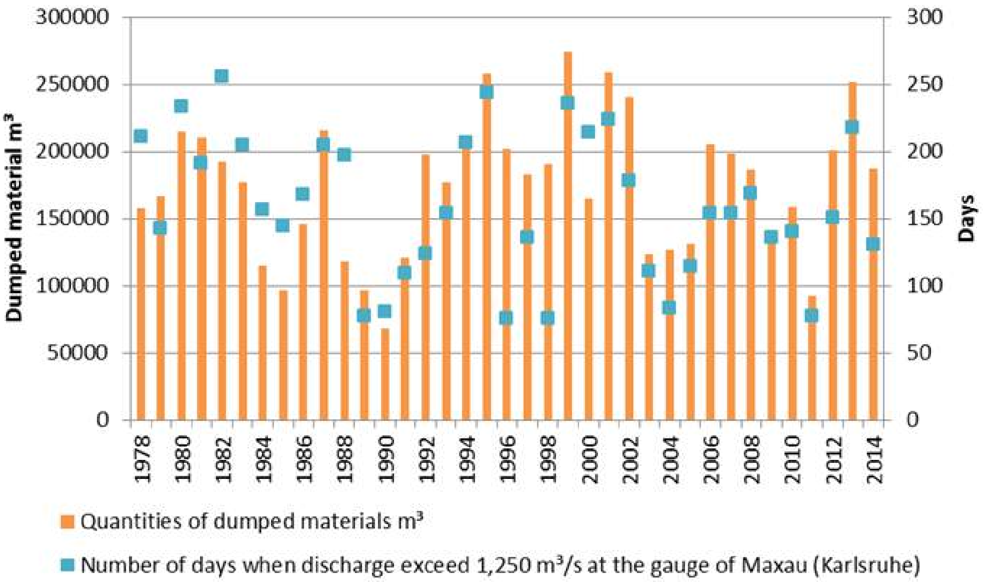


Figure 43: Correlation between dumped bed load material and number of days exceeding mean discharge

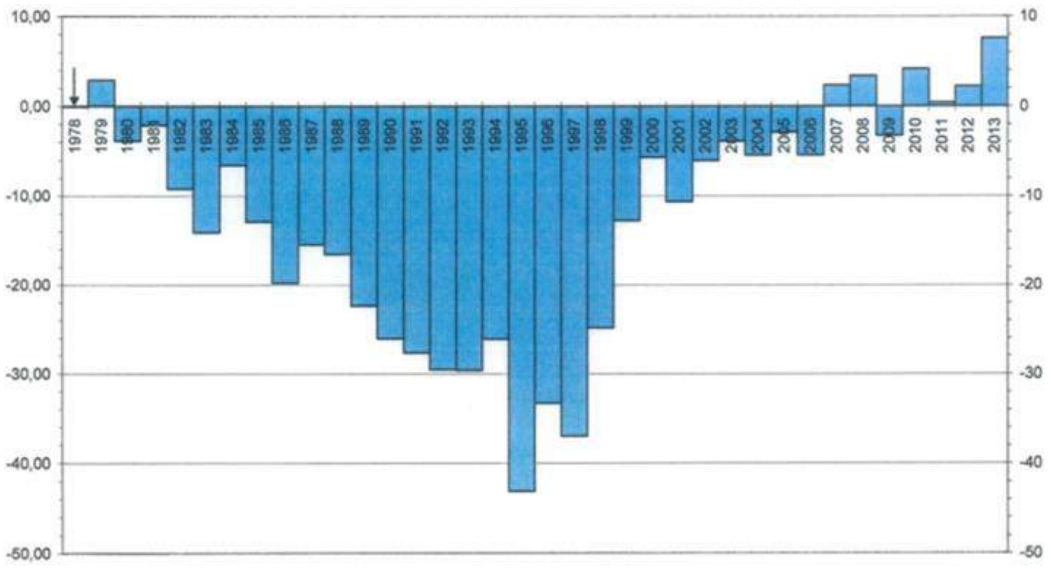


Figure 44: Deviation from the initial water level at the Iffezheim

The project area starts at Rhine river-km 336.0 and ends at river-km 338.0, directly at the source of the riverbed erosion, where the river develops its full sediment dislodging force again after passing through the last hydropower plant. A successful placement method proved to be the dumping of a sand-gravel mixture directly from self-propelled hopper barges while moving

K) ARTIFICIAL BED LOAD SUPPLY AT IFFEZHEIM

Rhine

Germany, France

downstream. At the predefined site, the hopper barge is opened slightly and the sand-gravel mixture is spread over a 10–20 m wide and 50–300 m long bottom stretch of the Rhine. The settling of the material is monitored by hydrographic reference surveys to make sure that the fairway is not impaired.

The sand-gravel mixture is applied throughout the year by means of seven to ten hopper barges per day, loaded with 140–170 m³ each. On average 185,000 m³ (or 320,000 tons) of sand-gravel mixture with a diameter of 0–63 mm as well as 10,000 m³ (or 15,000 tons) of armour stone with 45–125 mm diameter are artificially supplied.

Between 1978 and 1981 most of the material (66%) was dredged material from previous construction works in the tail bay of the Iffezheim impoundment. Lacking coarse grain, additional material had to be supplied in form of gravel that was purchased from a gravel pit (34%). After 1982 the sand-gravel distribution has been changed according to the findings of studies on the natural bed material granularity. Without the investments in equipment, the costs of the bed load supply amount to roughly EUR 6.25 million per year.

Monitoring is necessary to ensure the safety and ease of navigation, to verify the success of the operation, to collect data for establishing mass balances and to calculate the cost of the operation.

Monitoring of the controlled bed load supply includes:

- Assessment of delivered material, i.e. the analysis of the grain-sized distribution, weight and volume of the delivered sand-gravel mixture,
- Bathymetric riverbed surveys at the placement site and on the reach about 14 km downstream, and
- Water level observation (36 gauges in the 14 km long river section).

Users and stakeholders

- National waterway administrations (German WSV and French VNF) are in charge of the project.
- Navigation benefits from an increase in navigable depth.
- Further key stakeholders, CCNR, environmental representatives etc. were/are involved in the project design and implementation process.

Key success factors and innovative aspects

- Grain-size distribution: The material should have the same grain-size distribution as the riverbed material. A small grain size or a high fraction of sand and fine gravel results in a fast moving bed load and therefore an increased need for material. A high fraction of large grains demands a stronger dislodging force to move the material downstream.
- Hydrographical survey and measurements of discharge and water levels: The reliability and accuracy of discharge measurements must be ensured. High accuracy in these surveys is mainly a result of experience and practical training on the equipment. While bathymetric surveys provide data related to mass changes in the riverbed, changed water levels at the

K) ARTIFICIAL BED LOAD SUPPLY AT IFFEZHEIM	Rhine Germany, France

same discharge is a meaningful indicator for the success of failure of the bed load supply. Data processing needs to be fast and reliable in order to react appropriately and timely to new developments.

- No damage is done to the environment through the measures. In contrast, it benefits the environment, e.g. the project prevented groundwater water levels to sink.

Time frame and status

In 1975 the first field experiments were conducted downstream the barrage of Gambsheim. The positive results of these experiments led to a German-French agreement in 1982. The increase of the navigable depth from 1.70 m to 2.10 m between Iffezheim and Karlsruhe was adopted.

The EWL was lowered. This had a negative effect on the placement stretch. During the 1990s water levels steadily rose until they reached the initial height measured in 1978.

Bed load supply is being enacted continuously. During the 36 years from 1978 until 2014 about 6,810,000 m³ of sand-gravel mixtures were dumped into the river without impairing navigation or environment.

Lessons learned

- Extended river groynes downstream of the placement site caused additional bed load transport. The mean water level could be maintained by lengthening the groynes at the placement site.
- When water levels decreased dramatically, the artificial bed load supply was supplemented by a partial riverbed stabilization using coarse particles. Since 1998 about 370,000 m³ of water building stones (with a mass of 15–45 kg) have been placed between river-km 337 and river-km 352.
- The reduction of the Equivalent Water Level (EWL) in 1982 worsened the situation at the placement site.

Requirements for implementation in other Member States

Depending on the local situation, contracts or agreements are needed for this approach to work in other Member States. If two countries are involved, both need to show the willingness of solving problems in an unusual way.

Further information/contact

Wasser- und Schifffahrtsamt Freiburg
Stefan- Meier- Straße 4-6, 79104 Freiburg, Germany

As regards to the ecological effects of fairway maintenance dredging, modern dredging strategies for maintaining fairway parameters should be based on the following principles:

- The extraction of sediments (for commercial or other reasons) contributes significantly to bed load deficit and in this way endangers the goal of achieving the "good ecological status" or the "good ecological potential" of surface water bodies according to the EU's Water Framework Directive. It is therefore recommended that the excavation of sediments be prevented and that material dredged for fairway maintenance be inserted back into the river. Although it is clear that good environmental status in a river also requires a "good sediment status", more knowledge is requiredon the various linkages between sediment mangagement and WFD objectives. The European Court of Justice`s decision in the Weser case is to be seen as benchmark for applying the WFD.

- In case of maintenance dredging for navigation on free-flowing sections of non-estuary rivers (e.g. annual dredging of fords), sediment dredged from the free-flowing stretch should be put back into the same free-flowing stretch of the river. The exact placement site needs to be evaluated case by case as well as whether the sediment can/should be immobilized or not.

- Furthermore, dredging activities should be harmonized with ecological needs, particularly concerning discharge and seasons or aspects like spawning periods of certain fish species. This refers e.g. to the time frame and the duration of dredging measures, to possible restrictions concerning the number of permitted parallel interventions, and to the way how the dredged material is reinserted into the river in an environmentally friendly way (e.g. only a certain amount of sediment at once, only from a vessel slowly moving downstream, only at certain water levels, etc.) (see Figure 21). These aspects need to be evaluated carefully and specifically for each project and are to be specified in the conditions of the respective legal permits.

7.3.2 Fairway realignment

If a major realignment of the fairway is foreseen, the waterway authority discusses the future new fairway course and the corresponding changes in fairway marking (buoys) with the operational unit of the navigation authority (navigation surveillance or navigation police). After agreeing on the decision, the navigation authority is informed about the changes and they publish a Notice to Skippers (NtS), informing the users of the waterway of the planned measure and the new course of the fairway. Decisions on fairway relocation are always based on up-to-date riverbed surveys that show deficits in fairway parameters.

Source: Plovput

Figure 45: Fairway marking works performed by the staff of Plovput on the Serbian Danube

The mounting and removal of buoys in the field is performed by means of marking vessels which are usually equipped with an on-board hydraulic crane for hoisting floating waterway marks.In most cases, buoys are anchored with a steel anchor. A steel rope connects the buoy to its anchor. Buoys for fairway marking are usually also made of steel, but synthetic materials may also be used, enabling an easier handling of buoys because of their reduced weight.

The Serbian Directorate for Inland Waterways (Plovput) has mastered the operational measure of shifting the fairway in the highly dynamic Danube stretch "Futog". Their responsive fairway realignment and fairway information system is considered a Good Practice Example (see next page).

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L) RESPONSIVE FAIRWAY REALIGNMENT AND FAIRWAY INFORMATION

Danube
Serbia

Problem/topic

Is it possible to apply fairway realignment activities without any dredging measures? Are these activities sustainable? On which kind of river stretch could such activities be applied?

Objectives

- To preserve fairway continuity (i.e. to provide sufficient depth and width of the fairway).
- To provide dynamic information on available fairway parameters during low water periods.

Background information

Sector "Futog" (river-km 1,267 to river-km 1,261) is located on the river Danube upstream of the Serbian city of Novi Sad, just at the edge of the influence of the Iron Gate reservoir. Due to its high morphological dynamics it is one of the most critical sectors for navigation on the Serbian Danube, limiting fairway parameters during low water periods. In most cases, the movement of sandbars does not influence the entire river width at the same time. This enables a realignment of the fairway.

Description of activities

In the first step hydrographic surveys are performed. The data is stored in the hydrographic database and analysed in comparison to the earlier survey results, establishing a pattern of the local sedimentation and being able to forecast morphological development in the near future until the next survey is done.

After analysis, the new fairway trajectory is designed and plotted into the layout of the sector and into navigational charts, including the position of the existing and new floating navigational marks (buoys).

In the next step the most critical cross section of the new layout is selected automatically within the integrated waterway information and management system. This enables calculations of the available minimum and maximum fairway depth and width at Low Navigation and Regulation Level (LNRL). In addition, relative fairway parameters are continuously merged with daily hydrological data, enabling the provision of real-time information on the available fairway parameters.

All dynamic fairway information is published at the online Navigational Bulletin, the Fairway Information Service Portal of the Directorate for Inland Waterways – Plovput. Access to the portal is free and unlimited: www.plovput.gov.rs/navigational-bulletin.

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L) RESPONSIVE FAIRWAY REALIGNMENT AND FAIRWAY INFORMATION

Danube

Serbia

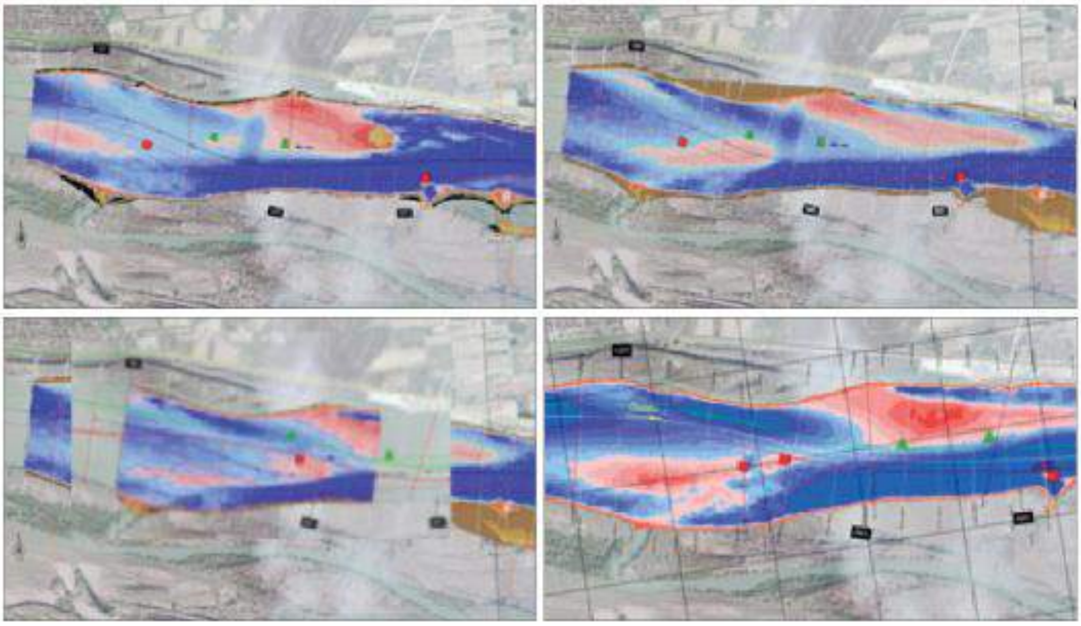

Figure 46: Layouts of the critical section Futog from 2013–2015

Users and stakeholders

- Skippers
- National waterway authorities

Key success factors and innovative aspects

The long-term analysis of the riverbed morphology and sediment back-filling rates (enabled by the application of Plovput's integrated fairway information and management system) showed that fairway realignment procedure at the critical sector Futog is feasible and cost-effective.

Time frame and status

The duration of one complete fairway realignment and information provision operation lasts five days, as presented in **Table 4** (see next page).

If needed, such a procedure can be repeated several times per year, depending on the prevailing hydrological and morphological conditions.

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L) RESPONSIVE FAIRWAY REALIGNMENT AND FAIRWAY INFORMATION

Danube

Serbia

Table 4: The general timeframe of a fairway realignment cycle at the critical sector

Activity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Indication of morphological changes received by the waterway marking staff	■					
Decision on execution of the hydrographic survey	■					
Execution of the hydrographic survey		■	■			
Entering data into hydrographic database			■	■		
Analysing and plotting the new fairway				■	■	
Fairway realignment in the field					■	■
Sending the official data to the Harbor Master's Office						■
Providing the new data for the Navigational Bulletin						■
Start of new fairway monitoring cycle						■

Lessons learned

Fairway realignment activities are applicable on morphologically dynamic river stretches with sufficient width (in case that morphological developments do not influence the entire width of the river), leaving sufficient space for fairway realignment. In order to apply fairway realignment it is necessary to perform regular hydrographic surveys and to monitor riverbed dynamics.

Requirements for implementation in other Member States

It is necessary to perform an analysis for each critical sector separately in order to determine applicability of regular fairway realignment procedures. Regular, frequent hydrographic survey activities are a precondition for fairway realignment, enabling waterway managers to understand the morphological processes.

Further information/contact

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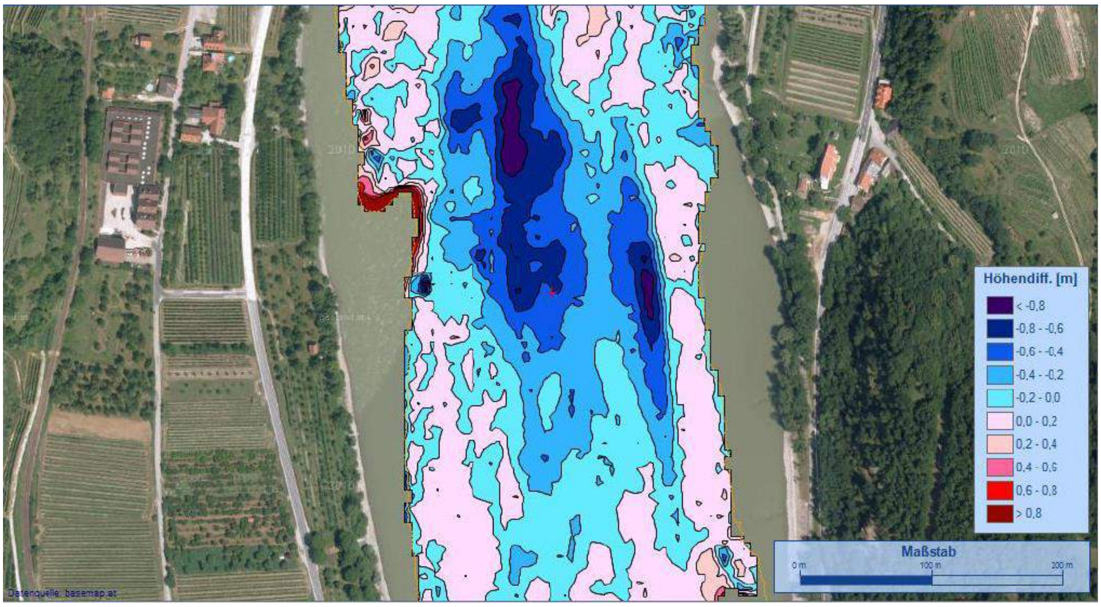
7.4 Evaluation of measures

The term "evaluation" is understood in this chapter as the assessment of the effects that fairway maintenance measures (i.e. maintenance dredging works or repositioning the course of the fairway) have on the availability of targeted fairway parameters (i.e. depth and/or width of the fairway). It is based on monitoring the hydro-morphological changes in the riverbed (see Chapter 7.1), while monitoring the ecological effects of measures is not in the focus of this Manual. The types and purposes of environmental monitoring are succinctly illustrated in PIANC 2009.

An indispensable prerequisite for any evaluation of the effects of fairway maintenance activities is a sufficient number of hydrographic riverbed surveys. Only if a certain density (i.e. number, of bathymetric surveys) and a certain minimum quality of these measurements is available, the success of fairway maintenance activities can be evaluated. Thus, both the density and the quality of hydrographic surveys must comply with a certain minimum service level which is sufficient to enable an adequately accurate monitoring and evaluation of specific fairway maintenance measures. Only a systematic evaluation of bathymetric riverbed surveys in combination with a detailed analysis of factors influencing riverbed dynamics will enable an assessment and optimization of fairway maintenance measures. Hydrographic monitoring is a recurring process and is performed before, during, after, and in between of any fairway maintenance measure.

A computer-aided evaluation of hydrographic riverbed surveys will allow to track the hydro-morphological development of the riverbed in a certain river section. Changes that occurred in a river section between different survey dates may be visualised on a map showing erosion and sedimentation patterns (Figure 47).

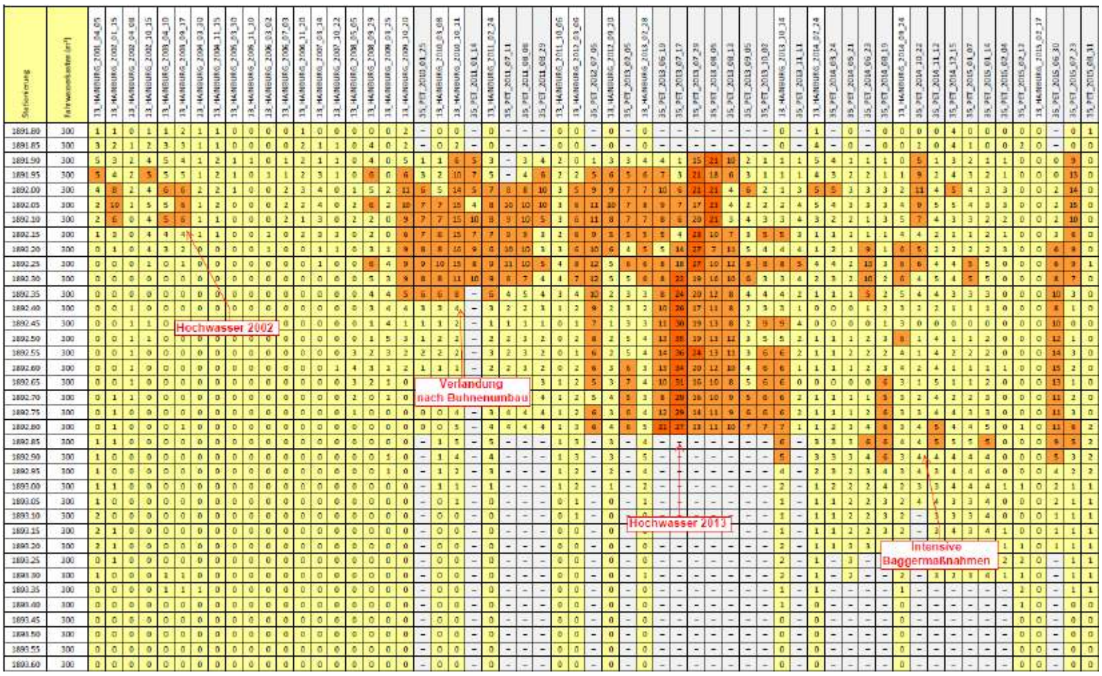


Source: via donau

Figure 47: Erosion and sedimentation patterns visualised as the difference in absolute heights above Adriatic Sea between two hydrographic riverbed surveys of the ford Schwallenbach in the free-flowing section of the Wachau on the Austrian Danube; blue areas = erosion, red areas = sedimentation

An alternative computer-aided visualisation of sedimentation processes is a matrix analysis; such as it is performed on the Austrian Danube for specific critical locations (fords) in both free-flowing sections of the Danube (see Figure 48). Here, 2D cross profiles of the riverbed, which are available for every 50 m (and sometimes 25 m) from periodic riverbed surveys, are evaluated in such a way that sedimentation within the fairway (depth and width) can be visualised in a percentage rate of the 2D area of the fairway. Figure 48 visualizes sedimentation for a specific critical location with a length of 1.8 km on the Austrian Danube east of Vienna during the years 2001 to 2015. In the graph, the y-axis shows the chainage (river-km) for the 2D cross profiles (distance of 50 m), while the x-axis contains the values for sedimentation in percent of the area of the fairway according to all available hydrographic riverbed surveys for this section.

Such a matrix analysis allows to easily detect trends in sedimentation and erosion patterns over a specific period in time and enables inference of the characteristic "behaviour" of a certain critical location. A matrix analysis can also be performed for the area situated below the fairway rectangle (depth and width of the fairway) in order to track riverbed degradation processes or alterations in the thalweg of the river.



Source: via donau

Figure 48: Matrix analysis of sedimentation processes in the free-flowing section of the Danube in Austria east of Vienna for the ford “Petronell Witzelsdorf” in the years 2001 to 2015; yellow = 0-5% sedimentation of the area of the fairway, orange = 5-20% sedimentation, red = more than 20% sedimentation, white = no values available

The targeted effects of a specific fairway maintenance measure include both the re-establishment of defined fairway parameters and the period of time in which these parameters will be available respectively deteriorating after implementation of the maintenance measure. The duration of a measure's impact ends if the current values for quality criteria (e.g. the availability of infrastructure) fall below predefined limits. The impact can be determined by calculating the time from the removal of sediment from the fairway until the complete backfilling of the removed sediment – i.e. when the backfilling rate reaches 100% (see Figure 49). The duration of the impact of the measure can be defined as the time period in which, compared to the zero alternative ("doing nothing"), an increased availability is given. Thus, the measure with the highest impact on availability compared to necessary measure cost per time unit must be considered as favourable.

Due to the specific characteristics of different waterway sections, such as discharge, slope or sediment types, the backfilling rates for critical locations on different river sections show a different behaviour. Without prejudice to the legal, economic and environmental framework for fairway maintenance measures, the optimal timing of a dredging measure for a certain critical section may be determined by a variation of the time of dredging and the assessment of the subsequent backfilling behaviour.

In computer-assisted waterway (asset) management tools (see Chapter 7.2.2), the exceedance of a specific level in the backfilling rate (e.g. 50% or 70%) may be used as a threshold for an early warning system, triggering a notification of reduced fairway availability. For different alarm levels different countermeasures may be defined and a dredging intervention maybe prepared in sufficient time.

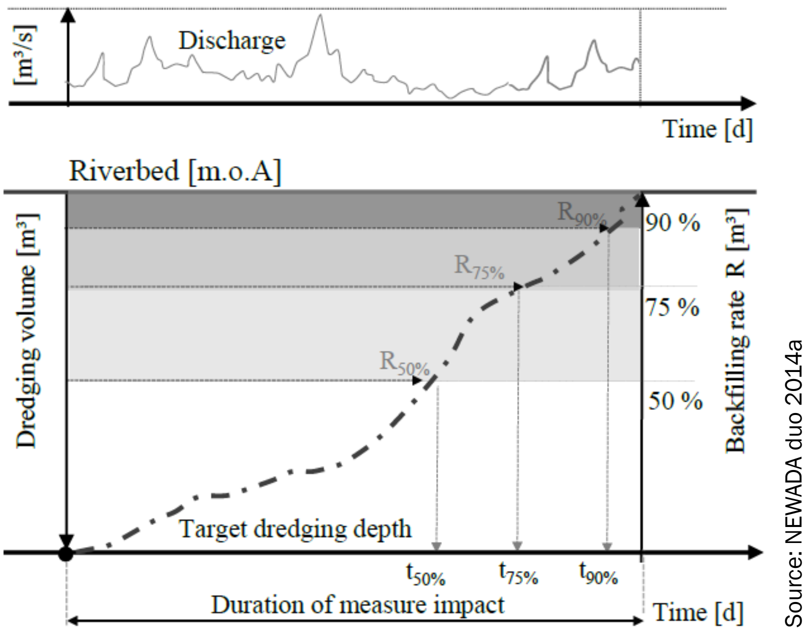


Figure 49: Duration of a dredging measure based on the typical backfilling rate of dredged material in relation to the discharge in the time period

Based on an analysis of historical data of water levels and riverbed surveys for a period of 10 to 30 years, the characteristic "behaviour" of a specific critical location or section can be derived as an empiric function of various impact parameters, such as back-filling rate (in dependence of discharge, flow velocity and distribution of suspended load and bedload), impacts on aquatic flora and fauna, as well as costs.

Regarding free-flowing sections of natural rivers which are showing riverbed degradation due to reduced sediment transport volumes caused by weirs or hydropower plants, the placement site for re-inserting sediment into the river should be positioned in the same free-flowing stretch in order to keep sediment balance mitigate further riverbed degradation by erosion. In such cases, an evaluation of the distance between the dredging and placement sites of specific fairway maintenance measures is essential in order to optimise this distance with a view to keeping sediment longer in a specific river stretch. The general question here is how sediment management can be improved by re-inserting the dredged material into the river and by optimising the selection of suitable potholes (i.e. deeper areas of the riverbed) in order to meet the requirements of fairway maintenance and ecology. The specific aspects involved here can be addressed as following:

- In which way does a longer distance between dredging and placement sites influence the backfilling rate at the original dredging site? In which way are shallow areas positioned in between the dredging and dumping sites affected?
- What is the "behaviour" of dumped material in different types of potholes or deeper areas of the riverbed (re-mobilisation rate of sediment)? How long is the time span between dumping into and erosion out of a pothole?
- What is the effect of longer distances between dredging and dumping sites with regard to the duration and the economic aspect of maintenance measures? Which additional expenditure of time will be caused by longer transport distances? Which additional costs are incurred by longer transport distances?
- Is different/additional equipment necessary for performing fairway maintenance measures if longer distances are involved? How many (hopper) barges are required? Can the targeted weekly performance (cubic metres per week) be met? Which power is necessary for the used equipment?

7.5 User integration and information

User-oriented fairway maintenance aims at applying the best methods for transmitting relevant information to users and at getting the necessary information from them. This includes not only *informing* in the best way, but also *consulting* and *integrating* the users in the course of the maintenance process. It is crucial that decision-makers in politics as well as in the waterway administrations are willing to accommodate customer’s expectations into the process. There are three different steps of user integration (see Figure 50), which shall be described here in detail.

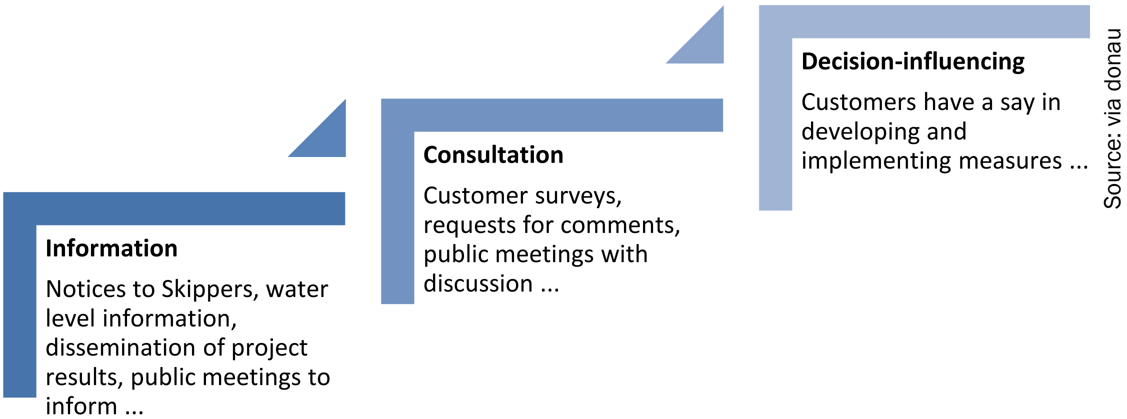


Figure 50: Steps of user integration

Information

National and local fairway authorities have the obligation to inform users about issues regarding the waterway that might influence safety and accessibility. The type of information and the transmission tools have to meet the requirements of manifold user groups (e.g. skippers, logistic service providers, waterway administrations, dredging companies). Information has to be accurate, up-to date and easy to access. In the best case it shall be available on one single online platform per transport corridor.

River Information Services (RIS) are suitable tools and available for most inland waterways. But they differ in terms of extent and quality levels. Main elements are notices to users. These may include the status of inland waterway infrastructure (fairway, bridge and lock parameters) or failures of aids to navigation. Skippers have to be informed about temporarily blockages of waterway sections or other types of infrastructure, maintenance works or other projects, current water levels and water depth, ice formation and weather. Such messages are communicated to skippers via Notices to Skippers (NtS). The international NtS standard provides a standardized data format that can be used, both for pull-services (e.g. publishing of notices on the Internet) or for push services (e.g. distribution by e-mail).

In addition to information on fairway conditions, updates on maintenance activities, recent developments and planned measures are valuable to waterway users. This makes decisions more comprehensible and supports acceptance by the public.

Consultation

In order to increase customer satisfaction, waterway administrations make use of consultative instruments. Anonymous customer surveys help to evaluate their performance in connection with regular maintenance activities, or the provision of information, etc. Another approach permits customers to comment on proposals and to contribute ideas and suggestions to planned measures which may be taken into account at decision stage.

Decision-influencing

Waterway users and other interested parties have a say in developing and implementing maintenance activities. They may add a practical viewpoint to the decision, influence time schedules and set priorities.

Figure 51 illustrates the waterway maintenance cycle (see Chapter 7) by including stakeholders who may be informed, consulted or invited to influence a decision. Involvement strongly depends on the geographic area, the administrative structure and the expected effects of the planned measure.

In every case a cross-border and corridor-wide approach is crucial. In order to determine who should be included in which phase and to which extent, the following rules should be applied – regardless of the stakeholders' location.

- Inform: Share gathered data in a convenient way with everyone whose activities are influenced by the respective situation.
- Consult: Ask for the inputs from experts, if valuable or crucial information may be provided by them or if their interests related to the respective river stretch are touched.
- Invite stakeholders to influence decisions if they are dependent on the decisions a waterway administration may do.

In some cases a minimum level of involvement is mandatory. According to the EU's "Guidance Document on Inland Waterway Transport and Natura 2000" (EUROPEAN COMMISSION 2012b), maintenance dredging works which only maintain a certain state of infrastructure do not require an appropriate environmental assessment. Nevertheless, because of changing techniques, conditions or regularity of maintenance dredging works, an assessment to the extent that measures are likely to have a significant effect on the Natura 2000 site has to be carried out. This is usually achieved during the process of obtaining legal permits (as to water or environmental law) for maintenance dredging interventions. The assessment of environmental impacts and the compliance with European and national environmental law is undertaken by official legal experts which are nominated by the authorities in charge of issuing permits.

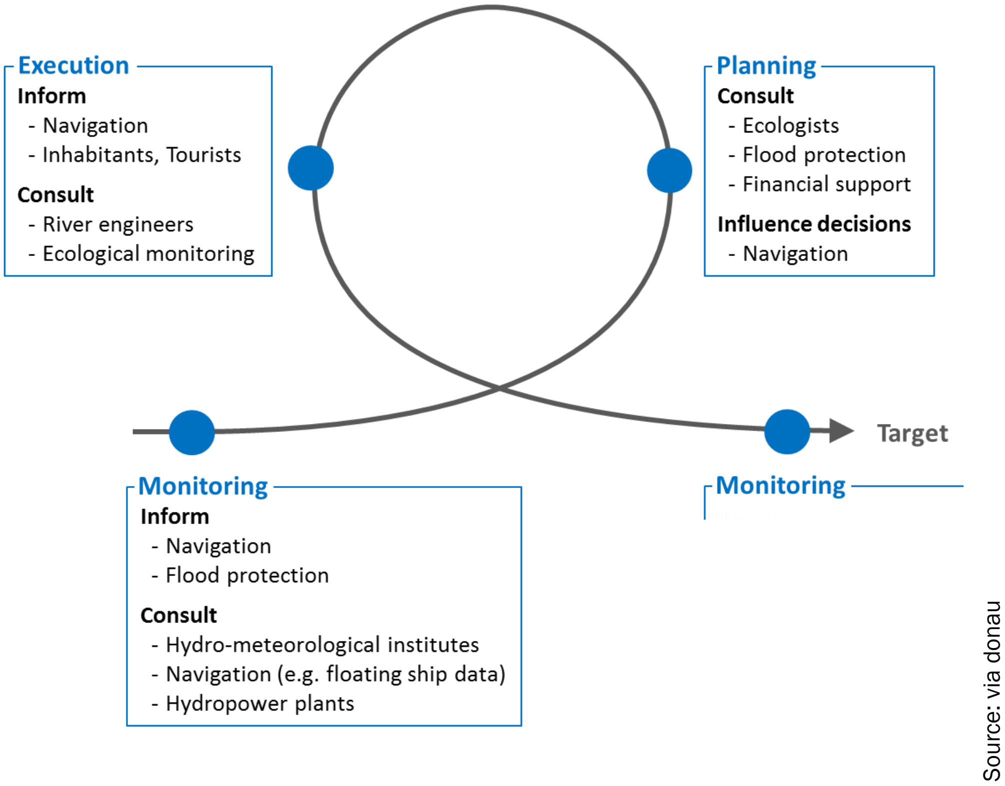


Figure 51: User integration in the waterway maintenance process

7.5.1 User information

In regards to user integration, the German Electronic Waterway Information System (ELWIS) is considered a Good Practice Example. It is a well-proven Internet, e-mail and text message service that has been successfully used by skippers and other groups for many years.

M) ELECTRONIC WATERWAY INFORMATION SERVICE (ELWIS)	National inland waterways Germany
Problem/topic	
In order to plan and perform efficient voyages, skippers are in need of up-to-date information on nautical, traffic-related and logistical aspects. Waterway administrations collect and generate such data, but in many cases there is no single platform where this data can be accessed. On the contrary, different tools are in use for different purposes.	
Objectives	
• To develop a consolidated portal that enables skippers and further user groups to quickly and easily access tailored information useful for voyage planning. • To increase efficiency, safety and environmental soundness of inland navigation by providing up-to-date information. • To fulfil the requirements of Regulation 416/2007/EC concerning the technical	

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M) ELECTRONIC WATERWAY INFORMATION SERVICE (ELWIS)	National inland waterways Germany

specifications for vessel tracking and tracing systems (Notices to Skippers).

Background information

ELWIS (Electronic Waterway Information Service) has been the Internet service of the German Waterways and Shipping Administration (WSV) since 1999. It provides data for all German waterways, but also Notices to Skippers (NtS) from selected additional countries. An e-mail and short message service (SMS) has been installed. The use of ELWIS is free of charge and data is accessible to all fairway users and interested parties.

Description of activities

ELWIS offers data relevant for nautical and operational purposes via internet, SMS and e-mail, supplementing traditional information methods (e.g. journal of nautical information). The online service consists of static and dynamic internet pages, e.g. for water levels, water level forecasts, ice situation reports, Notices to Skippers in 10 European languages, traffic management information, classification of inland waterways, and regulations and notes on shipping laws. Various authorities in charge keep the information up to date.

The ELWIS subscription is independent from access to Internet browsers. According to individually indicated interests, regular or event-controlled updates are sent automatically via e-mail or SMS. Customers may subscribe to relevant information updates on the above described services.

In order to improve the exchange of internationally standardized NtS a dedicated web service was introduced. This standardized data exchange is currently applied between Germany, Austria and Slovakia, and tested in cooperation with Hungary and the Netherlands. An extension is planned as soon as the NtS web service has been implemented in other countries.

Users and stakeholders

- Skippers
- Land-based users, e.g. logistics service providers
- Traffic and waterway authorities

Key success factors and innovative aspects

- The German WSV assigns a high priority to keeping the system up to date and providing current high quality information. This task requires a lot of resources. The high usage numbers confirm that this effort is very much appreciated.
- ELWIS does not only provide information on NtS but also shares a vast variety of related information services such as information on applicable legislation.
- The WSV fosters the further development of the NtS standard in Europe; German experts are very active participants of the expert group. Under their lead the web-service interface specifications were created and implemented for the first time. Now it is the basis for the amendment of the Commission Regulation.

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M) ELECTRONIC WATERWAY INFORMATION SERVICE (ELWIS)	National inland waterways Germany
Time frame and status	
Existing since 1999, ELWIS has been used intensely. In 2014 about 4.9 million users retrieved nearly 29 million pages. About three million e-mails were sent to recipients of ELWIS subscriptions. The NtS web service is accessed approximately 600 times a day. Presently the WSV is investigating the implementation of a vertical bridge clearance service within Notices to Skippers.	
Lessons learned	
By means of a comprehensive system the user needs can be met in an optimal way.	
Requirements for implementation in other Member States	
All relevant information should be provided to the different waterway users on a single platform. The user interface must be convenient and should also comprise mobile devices. The RIS Directive needs to be implemented in the respective Member State as a basis for the availability of the required data. The platform service provider needs to have easy access to relevant, accurate and regularly updated information. This implies clarification of availability, accessibility and protection of data with public and private bodies. For cross-border data exchange, additional harmonization of data content, format, interfaces and structure has to be pushed.	
Further information/contact	
ELWIS is provided by the German Waterways and Shipping Administration (WSV). Access: www.elwis.de	

In the Danube corridor, there exists the more recently established Fairway Information Services (FIS) portal. It provides comprehensive information to the users about, e.g., all the bottlenecks on the Danube flowing through seven countries from Austria to Romania.

N) BOTTLENECK INFORMATION ON THE DANUBE FAIRWAY INFORMATION SERVICES PORTAL	Danube AT, SK, HU, HR, RS, BG, RO
Problem/topic	
The Danube river is the most international river in the world. Ten riparian states are responsible for waterway management. It is crucial that waterway users have up-to-date information on the fairway status, as this is the basis on which they decide how much cargo may be loaded onto a vessel. In this respect, fairway depth at critical river sections is the most important information. The Danube Fairway Information Services (FIS) portal contains a joint and coordinated representation of bottlenecks in the fairway of Danube river and other fairway-related information	

N) BOTTLENECK INFORMATION ON THE DANUBE FAIRWAY INFORMATION SERVICES PORTAL	Danube AT, SK, HU, HR, RS, BG, RO

from most riparian countries.

Objectives

To provide one web portal for the users of the waterway in all relevant Danube languages. This portal shall contain information about fairway bottlenecks, water level information (incl. forecast), Notices to Skippers, ice messages, waterway objects (e.g. bridges, ports, locks), authorities and most important downloadable information from river administrations.

Background information

In the free-flowing sections of the Danube river the sediment transport changes the riverbed dynamically. Those changes influence the available fairway depth in bottlenecks, which can lead to restrictions for navigation with regard to the available fairway parameters. Through FIS the users now have guidance about the available actual water depth in bottleneck areas and they do not need to calculate themselves for each en-route bottleneck during the voyage planning.

Data on current water levels and hydrographic surveying results may be maximum one year old, if no relevant hydrological event occurred meanwhile.

The website provides a list about the most relevant bottlenecks from Austria to Romania. Details of each may be downloaded (in PDF format). It contains a general plan about the surveying information referenced to low navigation and regulation level (LNRL) or gauge zero of reference water levels.

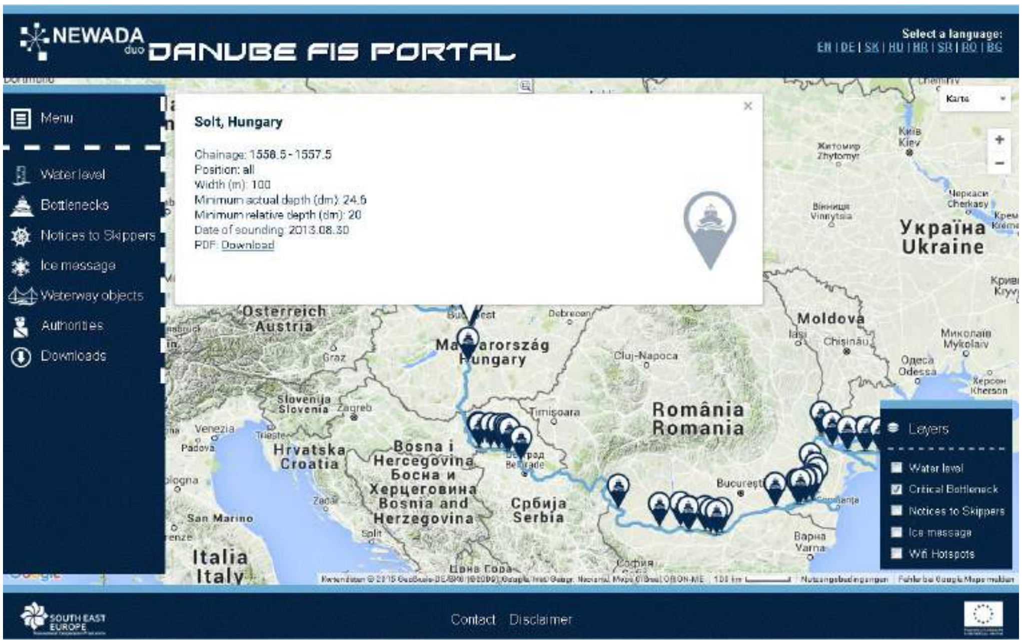

Figure 52: Representation of critical locations along the Danube. Detailed information about each single bottleneck may be viewed in an info box and downloaded

N) BOTTLENECK INFORMATION ON THE DANUBE FAIRWAY INFORMATION SERVICES PORTAL

Danube

AT, SK, HU, HR, RS, BG, RO

Description of activities

The minimum actual water depth is calculated based on the difference between the actual water level and the low navigation and regulation level at the reference gauging station, and the available minimum relative water depth, which is a referenced value to the low navigation and regulation level. The result shows the available water depth above the highest point on the riverbed in the area.

As one value is rather limited information about the area of a bottleneck, a general plan in PDF format is attached for download containing the latest available riverbed survey information for the specific location.

Users and stakeholders

- The web portal was developed for usage by skippers, shippers, logistical users and other interested parties.
- RSOE (Hungary) was the developer of the FIS portal. The Danube river administrations from Austria down to Romania provided data.

Key success factors and innovative aspects

This visualization is a summary of the information on bottlenecks from seven riparian countries. This makes voyage planning more comfortable for waterway users. Visualization of bottlenecks and database structure was harmonized.

Time frame and status

The portal was developed within the scope of the EU co-funded NEWADA (2009-2012) and NEWADA duo (2012-2014) projects. The bottleneck information was specified during the run of the NEWADA duo project.

In the future the information regarding the bottlenecks in all countries shall be automatized as much as possible.

Lessons learned

- The development of the bottleneck web service was a success, but it will need to be adapted to serve the needs of all administrations/countries.
- The display of bottleneck information (in table form and a PDF of the latest available hydrographic survey) will need additional harmonization.

Requirements for implementation in other Member States

Harmonized data input and display (up-to-date hydrographic surveying measurement not older than one year and related water level measurements at reference gauges), technical background.

N) BOTTLENECK INFORMATION ON THE DANUBE FAIRWAY INFORMATION SERVICES PORTAL	Danube AT, SK, HU, HR, RS, BG, RO
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The Austrian Waterway Management Company (via donau) delivered a Good Practice Example in regards to user information. Their "Navigability Analysis of the Danube" is based on long-term statistical analyses of hydrographic measurements and is aimed at supporting the shipping industry and the logistic sector by supplying information concerning statistics about the available vessel draught for the transport of different types of goods on the Danube river.

O) NAVIGABILITY ANALYSIS OF THE DANUBE

Danube

Austria

Problem/topic

Long-term statistical analyses of water levels deliver valuable information to waterway users from the navigation and shipping industry as well as the logistics sector.

Objectives

- To offer waterway users a tool to plan their transports in line with the statistically most probable fairway conditions for the transport of different types of goods throughout the year.
- To enable the shipping industry and the logistics sector to include inland waterway transport in their transport chains whenever it is most likely to be economically viable.

Background information

Although the organizational structures changed over time, time series of hydrological measurements have been archived systematically since decades at via donau. The navigability analysis includes daily measured water levels since 1981. This huge amount of data was analysed for the two reference gauges of Pfelling (Germany) and Wildungsmauer (Austria).

Description of activities

Data of water level measurements collected over the last 34 years were analysed in order to derive statistical indicators with relevance for inland waterway transport. In order to calculate the available draughts retrospectively current rating curves were used to calculate the discharge and subsequently the available fairway depth. Exemplary results of the analysis are:

- The range of water levels in the course of the year from 1981 to 2014, showing the long-term daily minima and maxima and thus indicating the probability of high or low water levels.
- The probability of different draughts available for each month showing that in spring and

O) NAVIGABILITY ANALYSIS OF THE DANUBE	Danube Austria

summer the probability of a draught of 2.5 m fairway depth is higher while in autumn and winter the probability is lower.

- Tables indicating the duration of an available draught below several thresholds to identify months and years favourable for navigation.

Users and stakeholders

- The Austrian Waterway Management Company (via donau) gathers and stores hydrographic measurements since decades and decided to prepare the data to suit the interests of waterway users.
- Results are presented to interested companies (i.e. producers of bulk cargo) in consideration of their specific types of goods and their characteristic stowage factors.

Key success factors and innovative aspects

Following points have ensured that the navigability analysis on the Austrian Danube stretch is appreciated by the users:

- Description of theoretical background (maximum vessel load considering volume and weight as limiting factors).
- Clear presentation of results using charts and figures with short explanatory texts on how to read and interpret the graphs.
- Customized arrangement of results and face-to-face presentation to interested (future) users of the waterway.

Time frame and status

The program started in 2013. Regular updates are performed continuously.

Lessons learned

Representatives of the navigation industry and the logistics sector appreciate the navigability analysis and consider the results useful for their purposes.

Requirements for implementation in other Member States

For the implementation of such analyses in other Member States, the following requirements have to be met:

- Gapless, daily hydrological measurements.
- Information on volumes of cargo holds and maximum loading capacity (tonnage) of commonly used ships on the respective river.
- Current water level rating curves and bathymetric surveys.

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O) NAVIGABILITY ANALYSIS OF THE DANUBE	Danube Austria
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7.5.2 User integration

In regards to user integration in the waterway maintenance process, the French waterway administration Voies navigables de France (VNF) established a Good Practice Example. They integrate users on national and local level by organizing regular user committees.

P) REGULAR USER COMMITTEES ON NATIONAL AND LOCAL LEVEL	National inland waterways France
Problem/topic	
There is a big potential in regards to improvement of user integration in the planning and implementation process of maintenance activities of European inland waterways. On the one hand, effective and stable possibilities for users to express their needs have to be offered, on the other hand, information on maintenance activities, future projects and recent developments have to be provided in a convenient and target-group oriented way.	
Objectives	
• To establish regular user committees. These meetings keep waterway users informed about recent activities and actual nautical conditions from an early stage on. More importantly, they ensure a service-oriented approach towards maintenance activities and infrastructure projects by offering the users an occasion to express their needs. • To ensure structured user involvement by a legally binding procedure.	
Background information	
Voies navigables de France (VNF) is legally obliged to organize quarterly national user committees. Local user committees must be held at least twice a year for each of the seven local branches. Specific information and discussion events on larger projects complement these activities. Since April 2009 VNF is entitled to determine maintenance and improvement periods during which navigation may be restricted or prohibited. These steps demand for extensive information of and discussion with waterway users.	

P) REGULAR USER COMMITTEES ON NATIONAL AND LOCAL LEVEL	National inland waterways France

Description of activities

National user committees are organized quarterly. One of the four is dedicated to regular maintenance works. The approved protocols are published on the VNF website after each meeting. Decisions of the VNF board on maintenance and improvement works are published in the official bulletin for French waterways.

Local user committees take place at least twice a year for all seven local branches of VNF and follow local working procedures. The first meeting is organized prior to the tourist season and focuses on nautical conditions and the services and activities provided in the last year. During the second meeting in the last quarter of the year, planned works for the upcoming year are presented and envisaged projects for the year after that are discussed. The local committees propose topics that shall be discussed at national level and point out projects which may require actions from VNF. Provisional dates are announced at the beginning of the year. An invitation and the agenda have to be sent out at least two weeks prior to the meeting. No longer than four weeks after the meeting, the transcripts have to be sent out. The participants may object to the contents within two weeks. Afterward this time slot VNF publishes the proceedings on its website. They contain a list of the topics that were discussed as well as actions expected from VNF, including a location and deadline.

In addition to the national and local user committees, large projects issue to targeted information and discussion events. Both, the internal coordination meetings and the participatory opportunities follow a sequence, which allows VNF to build on the outcomes of the previous meetings.

Users and stakeholders

- VNF organizes local and national committees and specific information and discussion events.
- The participants of these committees and events include representatives from freight business (shippers union, skippers union, shipping companies union, inland ports French federation), t ourism industry, environmental stakeholders, transport ministry and/or other specific local interest groups – each year, organizations attending the committee confirm their representative.

Key success factors and innovative aspects

- A standardized participatory scheme assures that VNF customers' opinion is heard regularly. Through this institutionalization customers are taken seriously and participate readily.
- The agreed rules of procedure include a timely notification of events, the issuing and revision of the proceedings, as well as the publication of the results.
- Among others, one of the purposes of those local committees is to set up a provisional maintenance & restoration schedule in compliance with neighbouring fairways authorities (non-French, or out of the VNF network – eg IW included in seaports domain).

P) REGULAR USER COMMITTEES ON NATIONAL AND LOCAL LEVEL	National inland waterways France
Time frame and status	
Standardized participatory schemes are implemented at national and local level since 2009 National & local users committees practically started running on april, 2009 in compliance with a national act dated dec 16th, 2008. This act referred specifically to the planning of maintenance & improvement works on the French IW network, but VNF took the advantage of this opportunity to set up a national & some local users consultation committees. Each local committee is in charge of setting up a local committee, as well as its internal rules and yearly provisional agenda. Local committees topics may be discussed at the national committee, on their own request.	
Lessons learned	
Local committees deal with very practical matters (locks working schedules, canals depth, banks condition, equipments in ports or along rivers, …) whereas the national users committee deals more with general topics : VNF maintenance & restoration strategy, users' satisfaction study results & conclusions, etc. (differs however from VNF regular board meetings). Those local committees efficiency leans very much on VNF's commitment in answering to the users questions or remarks, even if answers are negative (impossible to carry out such works, budget unavailable, etc.).	
Requirements for implementation in other Member States	
It is noted that local user committees should reflect the geographic characteristics of the inland waterway infrastructure and the interests of users connected to it. Besides a fixed number of representatives from freight and tourism industry and according to the topics on the agenda additional participants should be selected carefully. Depending on the state specific decision-making structures, authorized representatives should be present in order to come to solid agreements.	
Further information/contact	
Mr. Eloi Flipo Head of Cargo Transport Department Voies navigables de France (VNF) 175 rue Ludovic Boutleux, 62400 Béthune, France	

The Netherlands integrate users in the maintenance process too. By conducting regular user surveys they get feedback on the nautical services. This enables the authority to better address the needs and preferences of inland waterway users (see next page).

Q) USER SURVEYS ON SERVICES OF THE NATIONAL WATERWAY ADMINISTRATION	National Dutch waterways The Netherlands

Problem/topic

The Dutch Waterway Administration Rijkswaterstaat (RWS) wants to enhance their performance, provide a better service, improve their corporate image, and increase their knowledge. To achieve this, RWS started measuring satisfaction of the public and users in regards to their products and services.

Objectives

- To obtain management information in e.g. the underpinning of investments.
- To analyse trends, impacts on the corporate reputation, and to see whether policy goals (such as the ambitions of the business plan "OP2015") are achieved.
- To increase customer value by taking user feedback seriously and enabling them to express wishes, and to measure user support.

Background information

User enquiries and surveys are beneficial tools. They provide insight into customer value, allow monitoring of policy visions, and can give advice about adjustments of policies.

Description of activities

- Within the user surveys on RWS services, following activities are conducted:User satisfaction survey (GTO): Online or face-to-face questionnaires show the satisfaction of the public with the products and services provided by RWS.
- Digital customer panel: Online questionnaires measure the same group of people over a longer time period, e.g. residents along the A4 motorway.
- Stakeholders participate in stakeholder platforms and are enquired about projects (e.g. the renovation of bridges).
- Focus groups: e.g. traffic safety or the "cutbacks and efficiency program".
- Traffic surveys and investigations of influenced area etc. are conducted.

Figure 53: Gebruikstevreidenheid-sonderzoek Binnenvaart

- User councils are held locally: at least twiche a year (national user committee: 4 times a year)
- RWS publishes reports, factsheets, leaflets and gives advice to the users. RWS created the business plan "OP2015". A national user analysis is published annually. Each month the fact sheet "What does the audience think?" is released.

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Q) USER SURVEYS ON SERVICES OF THE NATIONAL WATERWAY ADMINISTRATION

National Dutch waterways

The Netherlands

Users and stakeholders

- Stakeholders are residents and other interested groups, local and other public authorities, contractors and users
- Users include the users of the three infrastructure networks: main roads, main fairways, railways and sea portsRijkswaterstaat acquires knowledge about user behavior and collaborates with local authorities. Behavioral effects and public support for measures create the framework for new research.

The different public stakeholders in the process have different forms of use of the survey data:

RWS Board: Results ambitions Business Plan (OP2015), Annual National User Analysis, monthly fact sheet 'What does the audience think'

Board staff: Users Council, Stakeholder collaboration (ANWB or Schuttevaer)

Regions: Evaluations of behaviour, planning of collaboration with local authorities

Dedicated departments: Measure specification based on information of user behavious, cratiion of new research frameworks.

Key success factors and innovative aspects

- As the management is involved, they are directly informed and the results can subsequently lead to better management decisions.
- Through these surveys, a multiannual program can be established that is tailored to the needs and interests of different users and stakeholders.

Time frame and status

It is a continuous program that has started in the year 2000 an is evaluated regularly.

Lessons learned

Many lessons are learned through the evaluation of the program and the willingness to make adjustments.

There is a broad variety of stakeholders and users; e.g.: road, inland navigation, passenger navigation, sea navigation and recreational boating. Every group needs a different approach in surveying and communication. Therefore regular evaluation and adjustment is necessary using the different forms of surveying.

Requirements for implementation in other Member States

For a successful implementation in other Member States, the management of the respective waterway administration needs to be confident of the benefits and has to facilitate such surveys.

Participation has be organiszed and managed; different user groups may use the survey data in different ways.

Q) USER SURVEYS ON SERVICES OF THE NATIONAL WATERWAY ADMINISTRATION	National Dutch waterways The Netherlands
Further information/contact	
Mr. Jan Bosland Rijkswaterstaat, Zee en Delta Directorate Network Development/Programming Department Visit: Poelendaelesingel 18, 4335 JA Middelburg Mail: Postbus 556, 3000 AN RotterdamThe Netherlands	

8 Synopsis and recommendations

Based on the experiences made in practical implementation, the following aspects may serve as guidelines for efficient and effective fairway maintenance:

8.1 Fairway maintenance

Regular fairway maintenance is an essential tool to prevent deterioration of fairway parameters and fairway infrastructure and must be seen on the same level of importance as structural (engineering) interventions. Especially when measures are prioritized on corridor level, maintenance needs to be taken into account to a much higher degree. The importance of fairway maintenance must be communicated to decision makers and stakeholders more intensely.

The fairway maintenance strategy applied by the responsible bodies shall be **integrative and sustainable** as described in Chapter 6.1, and take the various functions of a river into account (in particular ecological needs and flood protection). This includes **pro-active interventions** and the provision of a **continuous fairway channel** of sufficient depth and width at a defined low navigation reference water level. Implementing such a strategy will contribute to averting bottlenecks and emergency interventions, reduce negative effects on ecology, cost and the reliability of the waterway transport infrastructure.

8.2 Fairway maintenance cycle

Successful waterway maintenance requires multiple steps: monitoring the status of targeted fairway parameters and infrastructure, planning and executing maintenance measures and informing the users of the waterway in the best suitable manner (fairway information services). These steps are described in the **fairway maintenance cycle** (see Chapter 7). As an overall goal, the time between the identification of the requirement for a fairway maintenance measure and its implementation should be shortened. To do so, the effectiveness (result-oriented), efficiency (cost-oriented) and environmental soundness of each of these activities should be further enhanced. There is **significant potential for improvement** of these elements and their interplay within this process in most of the European countries.

As a general statement, the fairway maintenance cycle should be considered as a **continuous improvement process** with consolidation through standardization (see Chapter 6.2). Monitoring and evalulating the (short and long-term) effects of measures also play a key role.

The basis for such an improved fairway maintenance cycle is a **solid decision basis of high-quality data** that enables to identify the most suitable measures. In this respect, there is significant need for improvement in several European countries.

Monitoring and evaluating measures and their effects are key activities in the improvement process. Suitable performance indicators and long-term data series are prerequisites for this approach. These aspects need to be reflected for the respective waterways or their sections.

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8.3 Maintenance measures

Limited resources require a **prioritisation of maintenance measures** (see Chapter 7.2). The type, extent, cost, duration and scheduling of measures is dependent on the relevant targets, pursued maintenance strategy and available resources. The absolute prerequisite for a sustainable process is a solid data basis enabling efficient decision making and clear communications of plans and results. ed.

Maintenance dredging can not be completely substituted. However, **operational measures** (i.e. shifting the course of the fairway and/or narrowing of the fairway) are powerful alternatives to maintenance dredging. On rivers or river stretches showing a sufficient width of cross sections, they need to be considered as a viable option - they have a lower impact on the river, are usually cheaper and easier/faster to implement. The prerequisite for such measures is a solid and high quality data basis in order to identify and define the appropriate actions.

Furthermore, **structural (river engineering) measures** must be taken into account when developing maintenance measures, and vice versa. River engineering measures may have a great impact on site-specific conditions and reduce maintenance efforts. Future studies should investigate ways on how to improve the **interplay** between these two approaches and how an adjustment of one or both enhances the situation. However, due to the constant hydro-morphological changes in the riverbed of natural rivers, basis maintenance dredging works can also not be totally avoided by river engineering measures.

Corresponding to an **integral and holistic management of water resources** based on river catchment planning, measures in the context of inland waterway maintenance must be enacted in accordance with the environmental law, in particular with the demands of the **Water Framework Directive** (WFD). The implementation level of this European legislation is the national one: the environmental impact of maintenance activities is assessed in course of the official national approval procedures following water-, navigational- and environmental law. To evaluate if maintenance measures have negative effects on water quality elements is task of external experts and done within the legal approval process. In case such negative are expected, measures are still possible if the **exemption criteria of Art. 4.7** of the WFD are met. National authorities should be bound under the national law to apply these criteria prior to authorising projects.

As maintenance activities are usually smaller, but enacted on a longer, regular term, evaluation of each measure is as - generally speaking - not appropriate; **framework agreements** should be found. In the majority of cases, maintenance measures do not to have as strong an influence on the status of a water body as structural measures and thus usually do not entail severe conflicts with the Water Framework Directive. As the integrated strategy illustrated in this manual aims to identify the measure that is most benefitial to transport as well as environmental goals, some navigation-related measures can even improve the ecological situation.

No general recommendation regarding the **relocation of dredged material** can be given. A case by case approach shall be applied respecting that sediment dredged from a free flowing stretch should be put back into the same free flowing stretch of the river in order to preserve its sediment balance. The (if available) applicable sediment management plan might foresee not to reinsert the dredged sediment, which can be possible if it does not cause negative impacts on the sediment balance of the river stretch.

Whether reinserted sediment can or should be immobilized, e.g. by putting it back into groin fields, depends on the specific location and desired effects; this should also be decided on case-by-case basis. In general, the link of maintenance activities and sediment management within River Basin Management plans should be enforced.

8.4 Corridor-oriented approaches

A variety of **corridor-oriented maintenance approaches** is existing (see Chapter 6.3.4). These should be further elaborated, e.g. as regards to joint definition of targets (see Chapter 5.3), harmonized standards and data analysis, coordinated planning, execution and monitoring/evaluation of measures.

A **cooperative approach** is needed between national waterway management authorities, competent ministries (e.g., transport, environment), international river commissions and river protection commissions as well as different groups of stakeholders. On the national as well as European level, appropriate structures should be provided for supporting these coordination efforts.

8.5 Waterway management authorities

Currently, many public activities are **outsourced** and handed over to private companies. However, the capability to decide independently and act accordingly in order to safeguard public duties has to be secured at waterway administrations. This requires adequate financial resources, up-to-date equipment, sufficient and skilled staff as well as a neutral decision basis of precise and targeted data which is available in-house.

Concerning dredging interventions, **flexible multi-year framework contracts**, as described on page 94, might prove to be a good intermediate solution to balance public duties and outsourced tasks.

8.6 User integration and information

Communication with affected stakeholders and discussion of their views need to be designed in a structured process. In every case, inputs shall be evaluated and the results communicated. Also as regards user integration, the principle of proportionality must be taken into account: fully fledged participation processes for single maintenance measures are usually not appropriate.

In addition to securing the targeted fairway infrastructure parameters, providing fairway- and infrastructure-related information to users of the waterway – such as skippers, shippers and logistics companies – is a key element of an integrated maintenance approach. Improved and more detailed information on critical locations enables better use of the available fairway parameters. Thus, such information has to be up-to-date, focussed and designed in a user-friendly way to enable the use of its full potential. Also information activities should be subject to continuous improvement.

9 Outlook and further topics of interest identified by the expert group

Within PLATINA 2, no further activities of the European Group of Experts are planned. However, as this exchange process was considered very valuable and was highly appreciated by the participants and the broader audience adressed, it should be continued, especially as many topics were identified to be in need of further discussion.

In particular, a supplementary manual focusing on maintenance of lock facilities, weirs and bridges (also covering canals) should be prepared. Furthermore, the concept of "Good Navigation Status" needs substantiation. A further key topic refers to the interplay of maintenance and ecology and how mutual benefits can be leveraged.

The following list was identified in course of the expert group work and provides an overview of the topics that are in need of further discussion:

- Maintenance of locks, weirs and bridges

Fairway-related infrastructure items – mainly locks, weirs and bridges - are essential elements of the waterway network. Thus, appropriate maintenance of these elements is key to competitiveness of waterways. As they have different characteristics (to the fairway and to each other), separate analysis and specific guidance is needed. Especially maintenance of locks will be a main topic in the coming years.

- Elements and implementation of the "Good Navigation Status" (see chapter 5.1)

The TEN-T Guidelines (Art. 15) require Member States to ensure that rivers, canals and lakes that are part of the TEN-T corridors are maintained so as to preserve a "Good Navigation Status" while respecting the applicable environmental law. However, the elements that define such a status, the steps needed to operationalize and effectively monitor it on the various waterways of Europe have not been specified. This issue is taken up by a "Good Navigation Status" study contracted by the European Commission running from January 2016 – December 2017. Its results are expected to provide key input to this issue.

- Environmental aspects of fairway maintenance measures

Navigational maintenance measures – which always have to be enacted in compliance with the existing environmental law - influence the ecological situation of a river. These influences depend strongly on the specific site conditions. In addition to research on how negative effects of navigational measures can be minimized and positive ones can be further enforced, special consideration of the application of environmental law (especially of the WFD and its exemptions) in practice, on national scale, is required. This, for instance, refers to experiences on the issue of quality elements and status deterioration and on how to apply the exemption conditions as outlined in WFD Art. 4(7): Furthermore, identification of more suitable measures and the needed conditions are issues to further investigate.

Addressing these questions would most probably contribute to a better design of measures, avoiding delays in their implementation and create more security by supporting their implementation in accordance with existing environmental legislation.

Furthermore, the relation of waterway maintenance activities and sediment management is a promising topic. In particular, harmonized monitoring approaches for sediment transport and links of maintenance dredging and sediment management activities & plans and River Basin Management Plans are of interest. This also includes the handling of different sediment types, the use of dredged material and the optimised timing and location of dredging and disposal measures.

- Interplay between structural (engineering) measures and regular maintenance activities

As structural interventions on a river (e.g. groynes) influence the need for and effects of maintenance measures (e.g. regular dredging) and vice versa, further investigation of this interaction is advised. Improved design of structural measures could reduce the need for regular maintenance activities, whereas advanced maintenance concepts can reduce the need for capital interventions. Designing measures that make use of this interplay in an optimized way can improve the fairway situation and on the same time reduce intervention efforts. This results not only in cost savings, but is in particular benefitial to the other functions of a river. Especially regarding environmental functions, less and softer interventions contribute to an improved ecological situation. The various possibilities for such improvements need to be further investigated.

- Improved technologies and methods for measurement, analysis and forecast

A more detailed investigation of the type and quality of data needed for effective waterway management in relation to specific river (sections) is advised. Some waterway administrations have a comparably large amount of data available, which offers possibilities to conduct specific analyses and develop additional services. These possibilities should be exploited more efficiently on national as well as cross-border level.

Furthermore, improved methods for water discharge modeling and water level forecast should be developed. These aspects prepare the grounds for effective decision taking and long-term analysis and assessment of measures. Improved water level forcast is also of particular interest for the navigational users of the waterway to support them in optimizing the draught of vessels on specific trips.

- Transnational cooperation in training of staff

The work on the expert group has again shown the importance and surplus value of exchange between waterway administrations from various countries. Structured discussion of experiences from practise and sharing of knowledge has proven to be benefitial to all participants, not only within a waterway cooridor, but beyond. Such a platform should be continued, but is not the only possibility to foster exchange. Several participants have pointed out the importance of transnational cooperation in training of staff (e.g. exchange programmes). Some bilateral initiatives are existing, but cooperation in this field could be significantly improved and better structured.

- Target-group oriented information design

The different user groups of a waterway have different needs towards information content and design. Even within the group of navigational users, the requirements are varying. As targeted and high-quality information can significantly contribute to better exploiting the potential of the exisiting fairway conditions, this aspect has to be seen as a further key element of optimized waterway maintenance. Further development of content, frequency and quality of Notices to Skippers, surveying track-plots, fairway marking and signalling, water level forecasts, bridge clearance, historical data and prognosis, floating ship data etc. is necessary.

- Coordination of players in the planning process

As is it the case with structural interventions, different stakeholder groups are affected within the various stages of the maintenance process. Stakeholder consultation is part of the permitting procedures for maintenance activities and must follow the applicable legal framework. To which grade these processes are extended should be considered carefully, while keeping proportionality, efficiency and capability to act in mind. Ways to improve effectiveness of these processes should be examined.

Furthermore, improved methods for efficient capacity planning for maintenance (including in-house provision vs. contracting) should be investigated.

- Financing models for maintenance

Also cities and regions profit from a successful inland navigation sector. Thus, they take interest in sharing the costs for maintenance operations on locks, weirs and the fairway. It would be benefitial to investigate (short and long term) financing models between the national, regional and local authorities in this respect.

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11 Annex

11.1 Glossary

A

ADN – Regulation annexed to the European Agreement concerning the International Carriage of Dangerous Goods by inland Waterways (UNECE document).

AGN – European Agreement on Main Inland Waterways of International Importance.

Alluvial – Something made of gravel/mud/silt/sand deposited and formed by rivers or floods.

Alluvium – A fine-grained deposit, composed mainly of mud and silt, deposited by a river.

Apron – Layer of stone, concrete or other material to protect a structure's toe against scouring.

Aquatic dredged material placement – Dredged material placement options under which the dredged material is submerged under water and remains water.

Aquatic habitat – Submerged water communities in the sea, rivers, or lakes.

Automatic Identification System (AIS) – Automatic communication and identification system intended to improve the safety of navigation by assisting in the efficient operation of vessel traffic services (VTS), ship reporting, ship-to-ship and ship-to-shore operations.

B

Backwater – Water held back in a channel or stream by a dam ballasting intaking ballast water to enable the vessel to clear a bridge, increasing the draught.

Bank protection – (Engineering) works to protect the bank from eroding.

Bar – An elevated region of sediment (sand or gravel) that has been deposited by the flow.

Barrage – A facility for damming a river to control its water level.

Barge – A vessel without its own motor, it is towed/pulled by a tug boat.

Basel Convention – Convention on the control of trans-boundary movements of hazardous wastes and their deposits (1989).

Bathymetry – The study of underwater depth of water bodies, topography of a water body

Bed erosion – The deepening of a stream/river by erosion of its bed.

Bed load – The weight or volume of sediment rolled or moved by a stream along its bed in a unit of time.

Bed profile – A curve indicating the elevation and shape of a river bed; may be a longitudinal curve or a transverse curve at a cross-section.

Belgrade Convention – Convention regarding the regime of navigation on the Danube; signed in Belgrade on 18 August 1948; see Danube Commission.

Bend radius – Radius of curvature of the fairway.

Bottleneck – A section of the waterway with restricted fairway parameters, due to morphological, hydrological or traffic density related reasons.

Bulk – Unpacked cargo that is discharged via grabbers, diggers or similar machinery (e.g. coal, ore, grain).

Buoy – A floating device that marks the fairway allowing ships to navigate safely.

C

Calibration – Comparing accuracy of an instrument's measurements to a known standard; setting attributes and computational parameters so that a model properly represents the situation being analysed.

Canal – Artificially created waterway or channel, mainly for the passage of vessels.

Catchment area of the river (drainage area, drainage basin) – Includes the whole drainage area of a river and its tributaries, overground and in the ground.

CCNR – Central Commission for Navigation on the Rhine Central.

Central Danube – Navigable stretch of the Danube River between the Iron Gate (km 931) and the Hungarian port of Gönyü (km 1,794).

CEVNI – European Code for Inland Waterways, document of the UNECE.

Chevron – U-shaped river engineering structure with blunt nose and open end facing downstream; the current is diverted along both sides of the structure.

Container – Standardized transport unit.

Container vessel – A motor cargo vessel that has been constructed specifically for transporting containers.

Convoy – A formation consisting of one motorized and one or more non-motorized vessels (towed convoy, a pushed convoy, or a side-by-side formation).

Crest level – The level of the top of a hydraulic structure (e.g. gnoyne, sill, guiding bund, embankment).

Critical sector/section – Part of the fairway where no sufficient depth/width/vertical clearance is guaranteed and available.

Cross-section, profile – a plane, generally perpendicular to the centerline of the river or the fairway.

D

Dam – A massive wall or structure erected across a valley or river for impounding water.

Danube Delta – The second largest river delta in Europe; has a high level of nature protection.

Danube River Protection Convention – An international convention for cooperation on transboundary water management in the Danube River Basin; signed on 29 June 1994 in Sofia and entered into force in 1998.

DC – Danube Commission; an international intergovernmental organization established by the Convention regarding the regime of navigation on the Danube signed in Belgrade on 18 August 1948; since 1954 its seat is in Budapest; official languages are German, Russian and French.

Depth contour – A line on a map connecting points of equal depth below the hydrographic datum.

Design High Navigation Level (DHNL) – Design navigation level determined with the 1-D hydraulic model associated with the 1% duration of discharges over the 30-year period.

Design Low Navigation Level (DLNL) – Design navigation level determined with the 1-D hydraulic model associated with the 94% duration of discharges over the 30-year period.

Dike (or dyke) – An embankment or a levee for confronting water especially along riverbanks to prevent flooding of lowlands.

Discharge (Q) – The volume rate of water flow, including any suspended solids (e.g. sediment), dissolved chemicals and/or biologic material which is transported through a given cross-sectional area ($Q = A \times V$, where A is cross sectional area (m^2) and V is the mean velocity of water (m/s)).

Discharge regime – Characteristics of the discharge of a water body governed by factors such as climatic conditions or characteristic regional features of the catchment area.

Draught (draft) – The vertical distance between the lowest point of the hull or the keel and the maximum draught line.

Dredger – Device, machine, or vessel that is used to excavate and remove material from the bottom of a water body dredging excavation of sediment from the riverbed with floating equipment.

Dredged material – Material excavated from the riverbed.

Drought – Continuous dry weather that is without significant rainfall.

Dry dock – An enclosed basin from which the water can be pumped out (a ship gets waterborne into the dock, the dock gates close, water is removed, the ship stays on docking blocks for repairs or cleaning).

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Duration curve – A curve showing frequency with which given values are equalled or exceeded during a certain period.

E

ECDIS – see: Inland ECDIS.

Echo sounder – An instrument for measuring the depth of water by recording times for sounds to be echoed back from the riverbed.

ECMT – A classification scheme of European inland waterways (ranging from I–VII) created by the European Conference of Ministers of Transport (ECMT; French: Conférence européenne des ministres des Transports, CEMT) in 1992.

EFIP – European Federation of Inland Ports; comprising nearly 200 inland ports in 19 countries of the European Union, Switzerland and the Ukraine.

EIA – Environmental Impact Assessment.

Electronic Navigational Chart (ENC) – Database, standardized as to content; structure and format, issued for use with ECDIS on the authority of Government authorized hydrographic offices; contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which may be considered necessary for safe navigation.

Embankment – A levee, an artificial bank raised above the immediately surrounding land to redirect or prevent flooding by a river, lake or sea.

ENI – European Navigation Identifier.

ESPOO – Convention on Environmental Impact Assessment in a trans-boundary Context (UNECE).

EWL – Equivalent Water Level.

Etiage Navigable et de Régularisation (ENR) or Low Navigation and Regulation Level (LNRL) – Water level derived from the rating curve, defined for all navigable sections of the river, defined by the 94% duration of discharges over the 30-year period, on days without ice (defined by the Danube Commission).

EUSDR – Strategy of the EU for the Danube Region (Danube Strategy); macro regional strategy of the EU gathering 9 EU Member States and 5 non-Member States.

F

Fairway – The part of the waterway with targeted depth, width and vertical clearance which enables continuous navigation (definition applied in this document; see CCNR 2016)

Fairway channel – The navigable cross-section of the fairway with the minimum width and depth necessary for continuous navigation.

Fairway axis – Centerline of the fairway.

Fairway parameters – That is, depth and width of the fairway, vertical clearance and bend radius.

FFH Directive – Flora Fauna Habitats Directive is a EU directive in relation to wildlife and nature conservation. Its aim is to protect the approx. 220 habitats and 1,000 species listed in its Annex. The directive is a basis for the Natura 2000 network.

FIS (Fairway Information System) – Geographical, hydrological and administrative information regarding the waterway (fairway).

Floating crane – Crane installed on a floating unit.

Floating equipment – Floating structures carrying machinery used for work on waterways or in harbors (dredgers, elevators, derricks, cranes, etc.).

Flood control – Regulation of flood waters to prevent or minimize inundation of valuable property or land.

Flood probability – The likelihood that a flood of a given magnitude will be equaled or exceeded in a given period; the annual exceedence probability of a 10-year flood is 10%, an annual exceedence probability of 1% equals a 100-year flood.

Floodplain (flood plain) – An area of land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge events.

Ford – A shallow sector of the river that stretches across the whole width of the river.

Free-flowing river – Sections of natural rivers which are not impounded due to barrages such as hydropower plants or lock facilities and where water levels can be subject to considerable fluctuations.

G

Gauge zero – Elevation of the gauging station with respect to the mean sea level.

Gauging station – Equipment for measuring the water level of surface water bodies.

Geodetic survey – A survey that takes figure and size of the earth into account, used to precisely locate horizontal and vertical positions suitable for controlling other surveys.

Granulometric riverbed improvement – The use of coarse gravel to cover lower zones of the riverbed in order to halt riverbed degradation.

Granulometry (of the sediment) – Size of particles of sediment forming the riverbed.

Gravel – Unconsolidated rock fragments that have a general particle size range and include size classes from granule- to boulder-sized fragments.

Green buoy – Green floating navigation sign that marks the left boundary of the fairway.

Groyne (groin) – A river engineering structure built at the angle to the river centerline to deflect the flow into the fairway, esp. during low-water conditions.

Guide bund – A transverse river training structure aiming to narrow the riverbed and to divert flow into the fairway in order to maintain sufficient depth by increasing the natural sediment transport capacity.

H

Haut-Niveau Navigable (HNN) or Highest Navigation Level (HNL) – Water level derived from the rating curve, defined for all navigable sections of the river, defined by the 1% duration of discharges over the 30-year period, on days without ice (defined by the Danube Commission).

Hopper barge – An open vessel with a hinged bottom for transporting and dumping dredged material.

Hull – Watertight body of a ship or boat.

Hydraulic modelling – Application of specialized software packages in order to determine and predict flow velocity patterns of a river.

Hydrographic survey – A survey of the riverbed with specialized equipment in order to analyse changes of the riverbed and available water depth.

Hydrography – A branch of applied sciences dealing with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defense, scientific research, and environmental protection.

Hydrology – The study of the movement, distribution, and quality of water, including the hydrologic cycle, water resources and environmental watershed sustainability.

Hydromorphology – Physical characteristics of the river, including the riverbed, banks, connections with the landscape, including longitudinal continuity and habitat continuity.

I

ICPDR – International Commission for the Protection of the Danube River; a transnational body established to implement the Danube River Protection Convention.

Inland Electronic Navigational Chart (IENC) – see: Electronic Navigational Chart.

IHO – International Hydrographic Organization; established in 1921 as the International Hydrographic Bureau (IHB) with 18 nations as members; the headquarters are in Monaco.

Impoundment – River section that lies upstream of a barrage (e.g. hydropower plant) and is influenced by alterations in flow velocity and depth due to the barrage.

Infrastructure costs – Costs of constructing and maintaining (waterway) infrastructure.

Inland AIS – Inland Automatic Identification System: a tracking and tracing system for inland navigation.

Inland ECDIS – A standardized system for displaying electronic navigational charts for inland waters and associated information which displays selected information from proprietary electronic navigational charts for inland waters and optionally information from other sensors of the craft.

ISRBC – International Sava River Basin Commission; the first constitutional session was held in 2005, the permanent secretariat started to work on 9 January 2006, the headquarters are in Zagreb.

IWW – Inland waterway: rivers, lakes, canals.

J

Joint Statement – Joint Statement on Guiding Principles for “Development of Inland Navigation and Environmental Protection in the Danube River Basin”; developed by the ICPDR, the DC and the ISRBC.

K

Keel – The longitudinal structure along the centreline at the bottom of a vessel’s hull, on which the rest of the hull is built.

L

Load factor – Percentage of the maximum possible loading of the cargo vessel.

Lock (navigation lock) – Hydraulic system to overcome differences in height along a waterway, in which vessels may be raised or lowered by filling up or emptying out one or more lock chambers.

Lock chamber – A rectangular space located between gates of a lock in which vessels may be raised or lowered during locking.

Longitudinal dike (training wall) – A rock structure parallel to the river center line to confine the flow in the fairway.

Low Navigation and Regulation Level (LNRL) – See: Etiage Navigable et de Régularisation (ENR).

Lower Danube – Navigable stretch of the Danube River between the Iron Gate hydropower and navigation system (km 931) and the estuary of the Danube River into the Black Sea (including the Sulina Canal and the Kilia Arm).

M

Maintaining – To keep in a condition of good repair or efficiency.

Marking plan – Plan of the position and other attributes of the all floating and coastal signs for a certain fairway or a stretch of the fairway.

Mean discharge – Average quantity of water that flows through a certain cross-section of the river per unit of time on average over a certain period of time (m^3/s).

Mean High Water (MHW) – Mean of multi-year maximum water levels, the average water level measured at a water gauge over a specific period of time.

Mean Low Water (MLW) – Mean of multi-year minimum water levels.

Mean Water Level (MWL) – Mean water level over a multi-year period.

Mobile crane – A crane that is not fixed and can be moved or driven.

Morphological modelling – Application of specialized software packages in order to determine and predict morphological changes of the riverbed.

Morphology (of the river bed) – Describes the shapes of river channels and how they change over time.

Multibeam – Specialized equipment for hydrographic surveys used for precise 3D imaging of the riverbed.

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N

NAIADES – An EU action programme supporting inland waterway transport.

Natura 2000 – A network of protected areas designated under the EU Habitats and Bird Directive.

Nautical conditions – How suitable the waterway is throughout the year and whether available water depth is suited for commercial navigation.

Navigable waters – Waters of sufficient depth and width for navigation of specified sizes of vessels.

Notices to Skippers (NtS) – Information messages that can be sent by or on behalf of a competent authority to (inland) ships relating to situations or events that may impact the navigational status of the fairway.

O

P

PIANC –World Association for Waterborne Transport Infrastructure (former Permanent Association of Navigation Congresses).

Polluter pays principle – Principle recommended by the OECD and the EU that the polluter should carry the costs of measures required to compensate for or clean-up pollution.

Pushed barge – Vessel designed or specially equipped to be pushed (see: barge).

Pushed convoy – Group of vessels, one at least of which is placed in front of the motorized vessel propelling the convoy and is known as a pusher.

Q

Quay – A stone or metal platform lying alongside or projecting into the water for loading and unloading ships.

Quay wall – Constructed vertical or almost vertical wall to hold waterside cranes.

R

Radar reflector (active) – An electronic system that responds to a received radar pulse by transmitting a similar radar pulse; target detection is improved because the actively transmitted pulse is generally more powerful than would be the case with passive reflection.

Radar reflector (passive) – A device mounted on navigation signs or small crafts that provides a strong radar signature without consuming energy.

Red buoy – Red floating navigation sign that marks the right boundary of the fairway.

Revetment – See: embankment.

Rhine-Danube Corridor –One of the multimodal Trans-European transport Network corridors (TEN-T)

Riparian country – Country adjacent to a river (e.g. Danube riparian countries are Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova, Ukraine, Russia).

Riparian zone (riparian area) – The interface between land and a river or stream.

Riprap (rip rap, rip-rap) – Rock armour, rubble, or other material used to armor shorelines, streambeds, bridge abutments, etc. against scour and water or ice erosion.

RIS – River Information Services, harmonized information services to support traffic and transport management in inland navigation, including interfaces to other transport modes.

RIS Directive – RIS Framework Directive of the European Union (2005/44/EC).

River basin – The land area that is drained by a river and its tributaries.

Riverbed – The bed or channel in which a river flows; the bottom of a river.

rkm – river kilometer, the measure of distance in kilometres along a river from its mouth.

S

SEA – Strategic Environmental Assessment.

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Sediment load – The amount of sediment passing a cross-section of a river in a specified period of time.

Sediment transport – Movement of eroded soil and rock particles in water flow.

Shipper – Contracting body of a transport.

Sill (bottom sill) – An underwater structure constructed perpendicular to the fairway axis to prevent riverbed erosion.

Siltation – Pollution of water by fine particulate terrestrial clastic material, with a particle size dominated by silt or clay.

Singlebeam – Specialized equipment for hydrographic surveys, used for surveying of cross-sectional or longitudinal profiles.

Squat – Level to which a ship sinks while it is in motion compared to its stationary condition on waterways.

Stakeholder – A person, organization or a subgroup of an organization that have a common interest in a project or activity.

Stakeholder's participation – Ability and enabled possibility of stakeholders to participate in the planning and implementation of (infrastructure) projects (on the river).

Standby costs – Costs for keeping a ship on standby (excl. operational costs).

Stern – Rear part of a ship.

Strategic traffic image – Information affecting decisions of the users of River Information Services, displaying all relevant vessels in the RIS area, including their characteristics, loads and positions.

Sustainability – Utilization of a renewable system in a way that this system is maintained as far as its important characteristics are concerned and its stock level may be regenerated in a natural way.

T

t – Ton, a unit of weight equal to 1,000 kg.

TEN-T – The EU's Trans-European Transport Network (TEN-T) guidelines in regulation No 1315/2013.

Thalweg – A line connecting the lowest points of successive cross-sections along the course of a valley or river.

tkm (ton-kilometer) – Unit of measure of goods transport which represents the transport of one ton over one kilometre.

Towed convoy – Group of vessels towed/pulled by one or more motorized vessels.

Tracking and Tracing System – Part of the RIS; process of monitoring and recording the past and present whereabouts of a ship shipment, as it passes through different handlers on its way to its destination, through a network; tracing refers to where the product has been, while tracking refers to where it is going next.

Training wall – Longitudinal dike.

Transponder – Wireless communication display or control device that accepts incoming signals and automatically responds to them (combination of the verbs "transmit" and "respond").

U

UNECE – United Nations Economic Commission for Europe.

Upper Danube – Navigable stretch of the Danube River between Kelheim in Germany (km 2,414) and the Hungarian port of Gönyü (km 1,794).

V

Vertical clearance vertical clearance or distance between high navigation level or max regulation level and lowest part of the bridge construction in the navigation opening

Vessel – Inland waterway craft, including small craft and ferry boats, as well as floating equipment.

Vessel Traffic Services (VTS) – Shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway.

W

Water gauge (station) – See: gauging station.

Water level (or gauge height or stage) – Water height at a certain point in the cross-section of a water body.

Water level forecast – Estimation of water level in the near future.

Waterway – Any navigable water body.

Weir – A dam across a stream of a river, with the purpose of the production of electrical energy by backing up or diverting water flow.

WFD – Water Framework Directive; EU Directive (2000/60/EC) which harmonizes the legal framework for water policy within the Union.

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11.2 List of figures

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11.3 List of tables

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11.4 Expert Group participants

Table 5: List of expert group participants sorted alphabetically by surname.

Name & Surname	Organisation	Country
Mr. Martin Boros	Waterborne Transport Development Agency	Slovakia
Mr. Jan Bosland	Rijkswaterstaat	The Netherlands
Mr. Jan Bukovský	Waterways Directorate of the Czech Republic	The Czech Republic
Mr. Roman Cabadaj	Waterborne Transport Development Agency	Slovakia
Ms. Jannie Dhondt	Waterwegen en Zeekanaal NV	Flanders/Belgium
Mr. Lionel Diéval	Voies Navigables France	France
Mr. Eloi Flipo	Voies Navigables France	France
Mr. Thomas Hartl	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria
Ms. Petra Herzog	WSV Mannheim	Germany
Mr. Dusko Isakovic	International Sava River Basin Commission	Sava River Commission
Mr. Željko Milković	International Sava River Basin Commission	Sava River Commission
Mr. Ivan Mitrovic	Plovput - Directorate for Inland Waterways	Serbia
Ms. Jasna Muskatirovic	Plovput - Directorate for Inland Waterways	Serbia
Mr. Horst Schindler	Danube Commission	Danube Commission
Ms. Zuzana Sebestova	Waterborne Transport Development Agency	Slovakia
Mr. Romeo Soare	River Administration of the Lower Danube (AFDJ)	Romania
Mr. Sim Turf	Vlaamse overheid, Departement Mobiliteit en Openbare Werken	Flanders/Belgium
Mr. Eddy Vervoort	De Scheepvaart	Flanders/Belgium

Table 6: Other participants

Name & Surname	Function	Organisation	Country
Ms. Gudrun Maierbrugger	Expert Group Coordinator; PLATINA 2 WP Leader Infrastructure	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria
Mr. Andreas Bäck	PLATINA 2 Project Coordinator	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria
Mr. Michael Fastenbauer	PLATINA 2 Steering Committee Member	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria
Ms. Katja Rosner	PLATINA 2 Team Member	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria
Mr. Benjamin Ogungbemi	PLATINA 2 Team Member	via donau - Österreichische Wasserstraßen-Gesellschaft mbH	Austria

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11.5 Summary of site visits taken by the PLATINA 2 group of experts

The expert group convened at three different workshops to discuss relevant issues regarding maintenance, to review the draft versions of the manual and to exchange experiences during on-site visits.

11.5.1 Danube: Bad Deutsch Altenburg, Austria

Host: via donau, 15 Oct. 2014

Topic: implementing structural measures to reduce maintenance efforts

At the first constitutional workshop, the group of experts visited the dredging site at the ford Bad Deutsch Altenburg, situated in the free-flowing section of the river Danube east of Vienna. This river stretch is characterised by high flow velocities and coarse sediment. The sediment regime is disturbed by numerous hydropower plants. The hydropower plant operator is obliged to provide residual (missing) sediment to stabilize the river bed. The waterway administration via donau is working on a project design to reduce necessary dredging interventions to a minimum by implementing long term engineering solutions in the river (e.g. optimization of groynes and training walls, removal of riprap, reconnection of side arms). Specific requirements are posed by the location of the site in a national park (Danube floodplains). The sediment dredged at shallow sections is loaded onto hopper barges, transported upstream and released back into the river at specified sites to stabilize the sediment regime.

Figure 54: Maintenance dredging on the Austrian Danube (© Robert Tögel/via donau) (left); the PLATINA 2 group on the Serbian Danube (© Luka Krivokuca/PLOVPUT) (right).

11.5.2 Danube: Belgrade, Serbia

Host: Plovput, 20 March 2015

Topic: implementing structural measures and maximising possibilities of fairway realignment to reduce maintenance efforts

During the second study visit, a surveying vessel of the Serbian waterway administration (Plovput) took the participants to a critical section for navigation called “Preliv”, located in the free-flowing stretch upstream of Belgrade. Here, the Danube has a sandy riverbed and is morphologically very dynamic which creates numerous critical sections. Due to restricted budgetary resources, Plovput prefers to realign the fairway (by re-setting the buoys) to optimise the available depth and width, rather than to conduct repetitive dredging activities on locations with low back-filling rates. A main element in this process is the corridor-oriented fairway marking database that has been established in cooperation with partners from Croatia, Romania and Bulgaria (see Good Practice Example on p. 81). It provides a web-based overview of all current marking signs, including coastal signs and buoys in use and enables quick updates and little reaction times.

Thus implementing this database, malfunctions and updating of marking system can be performed fast and efficient.

The visited river stretch consists of the main channel and a side arm, which are divided by an island. As the side arm is slightly shorter and wider than the fairway, skippers often prefer to take this shortcut although fairway markings try to prevent the unauthorized side-arm passage. This often results in groundings (river bed collisions) as the side arm is too shallow. Establishing a physical connection between the island and the riverbank to prevent passages of the side arm is not possible due to nature protection requirements. Thus, the section is currently dredged if necessary, but a more sustainable approach will be needed in the future. Plovput presented an approach that envisages increasing flow velocities in the left and right bank area of the sidearm by inserting a chevron close to the island and another one further upstream where another sand bar reaches into the channel. At the same time, these structures would enable a controlled sedimentation process in dedicated areas.

11.5.3 Rhine: Iffezheim & Gambsheim, Germany & France

Host: WSV & VNF, 17 Sept. 2015

Topic: Artificial bedload supply

Iffezheim is the last hydropower plant on the Rhine before it flows downstream into the North Sea. The free-flowing stretch downstream of Iffezheim is lacking sediment and has experienced riverbed degradation for many decades. In order to avoid the construction of another barrage and to support a more natural and ecologically valuable river, a sediment management programme was set up (see Good Practice Example on p. 111). Gravel – corresponding to the grain size composition of the original bedload material – is placed into the river. In order to maintain the minimum fairway depth, the placement site has to be chosen carefully. Surveying vessels accompany the loaded hopper barges and confirm the exact spot. Sometimes the artificial bed load is dropped at once, at other times while in motion. After placement, the morphology of the riverbed is surveyed again. Depending on the river discharge, multiple trips per day might be necessary.


Figure 55: The surveying vessel leads the way to the exact placement spot (left), the hopper barge is opened to release the material (right) (© Katja Rosner, via donau).

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Topic: Fish passes at locks

Iffezheim and Gambsheim are hydropower plants situated on the River Rhine. Grounded on the European Water Framework Directive, waterway administrations and lock operators increased their efforts to support natural fish migration around artificial and natural barriers. In this regard a vertical slot fish passage facility was built in Iffezheim in 2000 consisting of several pools that support fish to overcome the large height difference and also allow them to rest in less turbulent corners . However, the velocity of water falling over the steps must remain great enough to serve as attraction flows for fish to the ladder. Three entrances were constructed from where the attraction flows are distributed over the whole river width. 2014 was an exceptional year as over 50,000 fish travelled through the fish pass by September. Prior to that, only about 25,000 migrated through it each year. The reason for the sudden increase in 2015 still has to be evaluated. The fish pass is constantly improved and the knowledge gained has also been used for constructing the fish pass in Gambsheim in 2006.

Topic: Lock management

A German-French treaty signed in 1969 enabled the construction of the Gambsheim lock which is operated by the French waterway administrations (Voies Navigables France). It is the largest navigational river lock in France with a length of 270 m and a width of 24 m. A modern traffic management system has been installed recently which is also used for disaster control. Action plans for emergency situations, such as the leakage of dangerous goods, accidents or floods have been set up. The station at Gambsheim also operates two polders, which may only be flooded and emptied according to the legally binding agreements with Germany.

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