Danube Transnational Programme

DIONYSUS

Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chains

WP title – P1 Transport Corridors and IWT Markets

O.T1.2 Fairway maintenance impact calculation tool

Version 4

Date: 18/02/2022

Status: Final

DIONYSUS_Calculation tool_4.0

Project co-funded by European Union Funds (ERDF, IPA, ENI)

Document History

Version	Date	Authorised
1	20.12.2021	
2	03.01.2022	
3	14.01.2022	
4	18.02.2022	

Contributing Authors

Name	Organization	Email
Doru Adrian MIHAI	MPAC	ampc@constantza-port.ro
Mihaela Cristina MIHAI	MPAC	ampc@constantza-port.ro
Daniel Răzvan JARNEA	MPAC	ampc@constantza-port.ro
Ana Elena STOICAN	MPAC	ampc@constantza-port.ro
Andra Roxana OPREANU	MPAC	ampc@constantza-port.ro
Cristiana Adina DIMA	MPAC	ampc@constantza-port.ro
Laura GEACU	MPAC	ampc@constantza-port.ro
Cristian Mihai ILIESCU	MPAC	ampc@constantza-port.ro
Georgiana MINEA	MPAC	ampc@constantza-port.ro
Dorin RAICU	MPAC	ampc@constantza-port.ro
Assoc. Prof. Nicoleta ACOMI, EngD	Atlas Research SRL	office@atlasreseach.ro
Senior Lecturer Ramona DUMITRACHE, EngD	Atlas Research SRL	office@atlasreseach.ro
Cristian ANCUȚA, EngD	Atlas Research SRL	office@atlasreseach.ro
Senior Lecturer Anca SÎRBU, EngD	Atlas Research SRL	office@atlasreseach.ro
Eng. Andreea-Maria UNGUREANU, BSc.	Atlas Research SRL	office@atlasreseach.ro
Daniela GHIUȚĂ, MSc.	Atlas Research SRL	office@atlasreseach.ro

Table of Contents

1 Table of Figures

2 Table of Tables

3 Abbreviations

Abbreviation	Explanation
CEMT	Classification of inland waterway ships and barges in terms of size
FRMMP	Fairway Rehabilitation and Maintenance Master Plan
HNWL	Highest Navigable Water Level
IWT	Inland Waterway Transport
LNWL	Low Navigable Water Level
MWL	Mean Water Level
t	tonne
UKC	Under Keel Clearance

4 Introduction

Inland waterway transport is a competitive alternative to road and rail transport and offers a sustainable alternative in terms of both energy consumption and emissions and noise.

Often the transport on the Danube has seen periods in which navigation was significantly limited and even closed for a large number of days due to shallow waters. In addition, blockages caused by frost have also contributed to inland waterway transport.

All these aspects are major impediments in increasing the share of inland waterway transport compared to other modes of transport, the business environment having difficulties to invest in an area with such vulnerabilities and a low level of predictability.

A summary of the problems caused by the lack of depth assurance as recommended by the Danube Commission includes:

- blockages during the summer, when there is not enough rainfall, which overlap with the season in which the demand for transport of grains increases;
- loading ships at low capacity with significant economic effects on transport operators, but also on all service providers related to river transport;
- increasing freight to ensure that additional costs are covered, leading on the one hand to economic losses throughout the supply chain and to disruption to the flow of goods on the other hand;
- changes in the structure of costs generated by increased fuel consumption and additional staff costs;
- a tendency to reorient transport solutions to other modes and routes with economic and social effects on companies in the field and the jobs they provide;
- efficiency of port terminals affected due to the fact that the low degree of predictability leads to delays and additional costs generated by non-compliance with operational process planning;
- penalties due to non-compliance with the clauses of the transport contracts and an increase in the risks of losing business partnerships.

Another undesirable effect is the considerable limitation of the development of container transport or the establishment of new logistics chains that include a component of river transport.

Therefore, an appropriate allocation is required to ensure the navigation conditions to be addressed: ensuring depth parameters (dredging), riverbed surveys, water level arrangements, availability of locks, ensuring water level information and forecasts, markings and weather conditions.

Taking these steps is a necessity that is part of the efforts to meet the objectives generated by public environmental policies (Green Deal).

4.1 Current context

The market for freight transport on the Danube does not depend solely on trade flows and the conditions of the economic framework at local / regional level. The volume of freight transport depends to a large extent on ensuring the minimum navigation parameters set by the Danube Commission. These parameters are depth and width, radius of curvature.

Failure to ensure the minimum parameters of the fairway influences both the activity and the financial situation of ship operators, as well as the possibility of attracting new flows of goods to river transport. Ensuring depths of navigation throughout the year has a significant impact on both the costs borne by river carriers and the share of inland waterway transport in relation to road and rail transport.

Lack of navigation depths may result in (A.P.M., 2021):

- blocking navigation on the Danube, especially during the grain transport season;
- loading transport vessels at low capacity (for example, if a barge at 2.5 m draft can be loaded with 2000 tons of iron ore, at a draft of 1.6-1.7 m it can load only 1000 tons);
- blocking of terminals in seaports, without expected cargo volumes;
- losses due to the fact that the cargo does not reach the final destination (maritime terminals) and the shipping vessels incur waiting periods for which penalties are paid;
- losses due to delays in meeting the deadlines in the transport contracts;
- for ship-owners, higher fuel consumption, increased labor costs and delays that can lead to the loss of contracts;
- possible loss of customer portfolios due to decreased confidence in the transport on the Danube

Therefore, ensuring the minimum depths for navigation is a decisive factor for the competitiveness of inland navigation. For long-distance transport, there may be critical areas where the minimum navigation depths are not reached for five to ten days. At present, without a proper instrument in place, it is difficult to accurately make a forecast of rising / falling water levels, a context in which loading barges at maximum capacity for safe navigation relies heavily on the practical experience of transport companies.

The actual depths of the Danube waterway have a significant impact on the cost of production of IWT services and, consequently, on the competitive position vis-à-vis other modes of transport, in particular rail and road transport.

The current situation of the insufficiently maintained section of the Danube waterway is a major disadvantage for ship operators to remain competitive and gain new customers as well as new types of cargo. Reliability of transport is an essential requirement for transport decisions that navigation on the Danube can only provide if all waterway administrations ensure the technological state of maintenance of the channel at the recommended depth of 2.5

m for 343 days per year and consequently, conditions homogeneous to allow ships to operate cost-effectively.

4.2 Objectives of the deliverable

Given the context mentioned above, for the development of the ***Fairway maintenance impact calculation tool***, an impact analysis on fairway maintenance was proposed, based on the history of situations encountered and reported upon, illustrating economic losses from barge operators (limitations of transport capacity, days of delay etc.).

The analysis of the history focused on the critical areas affected from the point of view of ensuring the navigability due to the insufficient depths on the navigable channel, registered on a time horizon of at least 10 years along the whole Danube.

The tool is based on a spreadsheet application. At the same time, the socio-economic losses resulting from the reduced transport of goods on the Danube were analysed.

The calculations that can be performed with the developed instrument will show the negative impact and, implicitly, the approximation of the losses caused by the failure to ensure the minimum parameters and in particular the depths of the waterway, in contrast to maintaining it at the planned depths and the effects on market profitability.

The instrument is addressed to representatives of the river transport industry (ship operators, port service providers, logistics service providers etc.), as well as policy makers at the political and public administration level. Therefore, the instrument is dedicated to contributing to a policy for the development of river infrastructure, based on facts and figures, for the Danube states.

4.3 Research methodology

Desk research

It involved researching relevant available documents on the subject area, provided by project partners or other organizations, as identified by the project team or following suggestions received from the beneficiary.

In order to conduct the office research, documents were identified and requested from the project partners and other relevant organizations to ensure an adequate knowledge of the field of study, so that the deliverable includes valid results based on well-defined input elements.

Such documents included, but were not limited to:

- Dionysus project documents, in order to properly understand the role of deliverables in the project and their correlation with the project objectives, but also with the other deliverables that will provide input for those covered by this report, but also those that would follow to have as input the results of this deliverable, such as the formulation of policies dedicated to the development of inland waterway transport etc.;

- documents that include statistics on Danube water levels;
- documents regarding the traffic on inland waters and the operation in the Port of Constanța of the goods transported on the Danube;
- documents regarding the organization of the transport on the Danube;
- legal and regulatory requirements regarding the transport on the Danube;
- recommendations and decisions that are subject to inland waterway transport;
- deliverables of other European-funded projects that have similar or related objectives to the Dionysus project (e.g. DANTE, DAPhNE, FAST Danube, etc.);
- studies and other documents that address the subject of the report.

The analyzed documents contributed to the identification of the factual situation and the way of organization and realization of the inland water transport in the last 10 years, as well as the limitations generated by the transport infrastructure.

Field research

It involved the collection of information directly from administrations (Annex 1), ship owners and other stakeholders (Annex 2) throughout the Danube basin, directly or with the help of project partners.

In order to carry out this stage, the research team established a list of relevant stakeholders, also by consultation with the beneficiary including authorities, inland waterway transport operators, logistics and shipping companies etc.

In determining and collecting information for deliverables, the general objectives of the project as well as the specific objectives of the deliverables were continuously taken into account.

The information collected was analyzed and structured in such a way as to achieve the expected results in defining the objectives of deliverables.

- Whenever necessary, the collected information was cross-checked to ensure its applicability in the project.

Software application

For the development of the software application for calculating the losses generated by the non-safety of the fairway, Java programming was chosen due to its portability and ease of use by potential users.

The input data included in the application are collected from documents published or communicated by the authorities, tonnage certificates or extracts provided by ship owners or other sources, as cited in this document.

These data can be supplemented by users with similar ones to expand the database used in performing economic impact analyses.

5 Analysis of the history of critical areas and situations where low depth affected inland navigation

5.1 Recent navigation conditions on the Danube

The Danube Commission[1] publishes an annual report on "*Observing the Danube Navigation Market*" (Danube Commission, 2021-2015) which shows the main aspects that have marked the Danube transport market every year. This includes issues related to the conditions of navigation, the fleet, the traffic of goods and their operation in the Danube ports.

The analysis of the data contained in these reports and other relevant sources reveals the following main characteristics regarding the navigation conditions on the Danube (a detailed presentation is included in the Fairway maintenance impact report carried out within the same project) (AtlasResearch, 2021):

2021 (first half of the year)

Due to the lack of ice during the winter, shipping operations were not interrupted in the first quarter of 2021. During this period, the water level allowed the ships to be loaded so that they had a draft of up to 2.5 m and sometimes even up to 2.7 m. In the following period, the depths remained relatively stable at 2.5 / 2.3 m.

2020

The absence of frost during the winter, as well as the precipitation in June ensured uninterrupted navigation in the first half of 2020. Sufficient water flow in the first quarter allowed the loading of ships at a draft of 2.5 m, and in March even at the maximum value of the draft of 2.7 m.

The rainfall in June made it possible to start sailing in the low water period earlier than in 2019 and keep the working drafts at a fairly high level for this period at 2.3/2.4 m.

Between November and December, due to the decrease in water levels along the entire Danube, the working drafts of ships, especially those of barges in convoys, were reduced to elevations of 2.0 / 2.1 m.

2019

In the first half of 2019, due to the lack of freezing phenomena, the navigation was uninterrupted. The water level allowed the loading of merchant vessels up to a draft of 2.7-2.5 m. In July, the temperatures were extremely high and there was a decrease in depth, the working draft of merchant ships decreasing to 2.3-2.1 m.

[1] [1] *www.danubecommission.org*

In the second half of 2019, the period of low water from and the lack of sufficient rainfall later, especially in October, led to a critical situation of significant limitations. As a result, ship-owners had to reduce the drafts of the convoys to 2.1 - 1.8 m, resorting to their opening and passing the barges one by one through the low water sectors, sometimes even the navigation being stopped.

2018

The absence of significant freezing phenomena ensured uninterrupted navigation. The water level in January-May and partly in June ensured maximum draft for ships of 2.5 m and sometimes even larger.
During the second half of 2018, the low water period in early July and the subsequent lack of sufficient rainfall led to a critical situation with significant restrictions on navigation due to water levels.
This was especially reflected in navigation on the Upper Danube and the Middle Danube, where the maximum draft was below 2.0 m, and in some areas problems arose, even with drafts smaller than 1.8 m. As a result, ship-owners had to organize partial transshipments to ensure a functional draft of 1.8-1.75 m, the passage of the barges one by one through the low water sectors, being periods of stopped traffic for both convoys with goods, as well as for passenger ships.

2017

In January, the water level was extremely low, around LNWL, and the river froze. Navigation on the Upper and Middle Danube decreased considerably. After taking measures to combat the frost events on the Danube, the navigation stabilized, being able to proceed with drafts of approx. 2.5 m in early March.

The hydrological conditions on the Danube were unstable in the second quarter, and by the end of May, the working drafts were no more than 2.3-2.2 m.

The low-water summer period began in June, and subsequent rainfall in the third and fourth quarters did not lead to a stabilization of hydrological conditions, so that drafts remained between 2.2 and 2.3 m from September to the end of 2017.

2016

In the first half of 2016, there were no significant stops in navigation due to extreme hydro-meteorological factors, which is why the conditions during this period can be considered satisfactory. The drafts available in the first quarter were around 2.5 m, and in the second quarter 2.3 to 2.2 m. In the third and fourth quarters of 2016, starting with September, the working drafts were reduced to 2.0 m.

2015

In the first half of the year no frost phenomena were observed which could lead to restrictions or closure of navigation; minor phenomena were observed only on the Lower Danube. Snow accumulations in the Danube basin in early March were insignificant.

At the beginning of July, the hydrological regime of the Danube was marked by a clear trend of transition to the low water phase leading to a sudden complication of the navigation situation.

At the end of July, the draft was limited to a value of less than 200 cm. As the depth in some areas has been reduced, the width of the waterway was also reduced.

Due to the reduction in the depth and width of the waterway on certain critical areas of the Lower Danube, it was necessary to reconfigure the convoys.

At the beginning of August, the levels continued to fall, with the values of lowering the levels being higher than in 2011, a critical year from the point of view of the low water level conditions.

2014-2012

The period was not noted as having significant periods with shallow waters leading to a significant impact on the limitation of navigation. Data on navigation conditions and critical areas on the Danube, including the number of days with water under Danube Commission recommended depth are presented in D.T1.2.4 Fairway maintenance impact report (AtlasResearch, 2021).

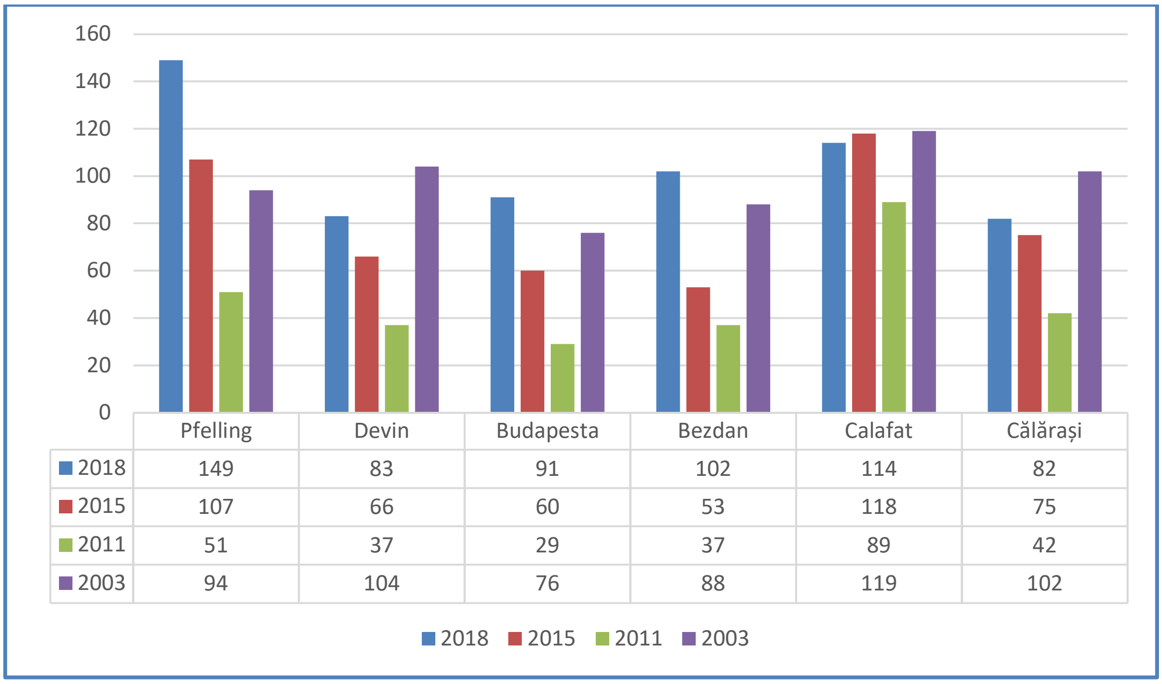
The review of the entire studied period highlights the fact that situations of significant navigation restrictions have been recorded periodically, the last year with problems significant being 2018, when the values of the absolute minimum of the last 70 years of observations were reached. (Figure 1)

The comparative analysis for each critical point in recent years shows significant discrepancies for the years with difficulties in ensuring the depths, as were 2003, 2011, 2015 and 2018.

The effects can be observed in other statistics on the quantities of goods operated in the Danube ports, or the number of ships that called in there (e.g. Port of Constanța - figure 2).

However, it should be noted that freight traffic, although directly associated with the conditions of navigation on the Danube, is also influenced by many economic decisions generated by the flow of goods in international trade.

Here we can particularly notice the flows of grains, which are influenced each time by the level of production (also related to the meteorological conditions), but also by the prices on the international market, which often fluctuate due to crisis situations such as caused by the COVID-19 pandemic.



	Pfelling	Devin	Budapesta	Bezdan	Calafat	Călărași
2018	149	83	91	102	114	82
2015	107	66	60	53	118	75
2011	51	37	29	37	89	42
2003	94	104	76	88	119	102

Figure 1 Number of days in which the levels at the main measuring stations were below the LNWL markings in years with long periods of restrictions on the Danube

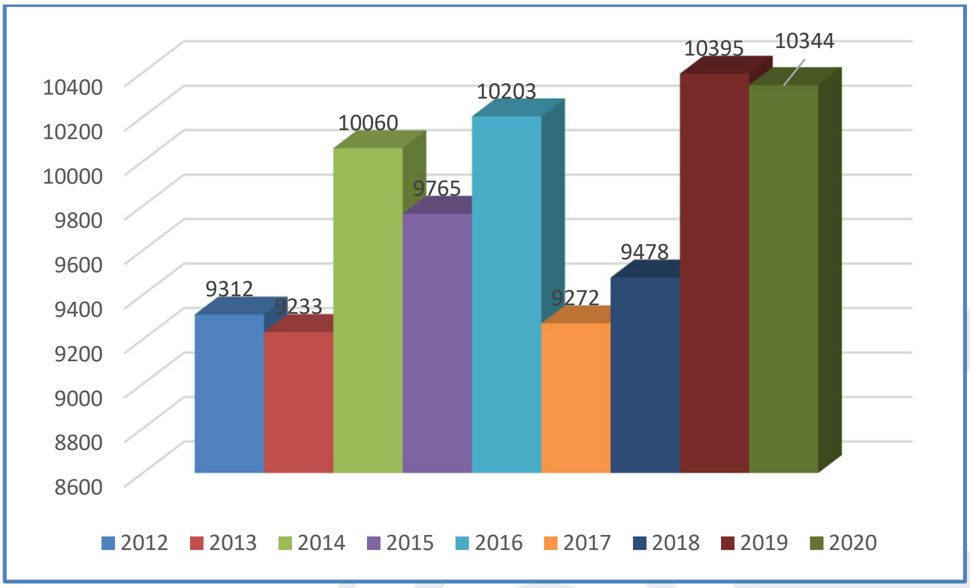


Figure 2 Number of river vessels that stopped in the Port of Constanța during 2012-2020

5.2 Critical areas restricting navigation on the Danube

As described in detail in D.T1.2.4 Fairway maintenance impact report developed under the same Dionysus project package, the Danube Commission regularly publishes reports from administrations including the following critical areas (AtlasResearch, 2021):

Table 1 List of critical points of the Danube

Country	*Critical point*
Germany	Lock Straubing to Port Straubing Sand
	Port Straubing- Sand to Deggendorf
	Deggendorf to Vilshofen
Austria	Wachau
	East of Vienna
Slovakia	part I. (km 1880 – 1863)
	part II. (km 1810 – 1785)
	part III. (km 1765 – 1710) including Nyergesújfalu
Hungary	Nyergesújfalu, with 60 meters wide fairway
	Nyergesújfalu, with 100 meters wide fairway
	Göd, with 80 me-ters wide fairway
	Dömös, with 120 meters wide fairway
	Budafok, with 60 meters wide fairway
	Solt, with 60 meters wide fairway
	Solt, with 100 meters wide fairway
Croatia	Apatin
Serbia	Apatin
	Futog
Romania	Bechet (100m fairway width)
	Corabia (100m fairway width)
	Turcescu (100m fairway width)

	Cochirleni (80m fairway width)
	Seimeni (100m fairway width)
	Prut (80m fairway width, depth > 7.32m)
	Tulcea (100m fairway width, depth > 7.32m)
Bulgaria	Somovit (km 610 - 607)
	Sredniak island Palets island (km 591 - km 584)
	Belene island Milka island Kondur island (km 569 - km 561)
	Vardim island (km 548 - km 540)
	Yantra River Giska Island (km 539 - km 530)
	Batin island (km 525 - km 520)
	Gostin island (km 476 - km 472)
	Mishka island (km 463 - km 460)
	Brashlian island (km 458 - km 455)
	Radetski island (km 441 - km 435)
	Kosui island Dunavets island (km 426 - km 420)
	Malak Preslavets island (km 414 - km 410)
	Popina island (km 408 - km 399)
	Vetren island (km 395 - km 390)
	Chajka island (km 386 - km 382)

The above list has been included in the software application database (*Calculation Tool*) described in this document, developed within the project in order to generate assessments of situations in which navigation on the Danube is restricted.

6 Analysis of socio-economic losses due to insecurity of the depths on the Danube

6.1 General aspects

The socio-economic impact of the limitations given by the periods when navigation on the Danube is restricted or even stopped is experienced directly by a large number of companies, including shipowners and port operators, but also indirectly by a wide range of companies across the economic spectrum, starting with inland waterway transport service providers and ending with manufacturing companies.

The latter often have to look for alternative solutions to ensure the continuity of the distribution of their products or to develop high-cost solutions that exclude river transport.

This chapter highlights a number of recent steps taken to analyze socio-economic losses and presents its own analysis based on data collected from administrations, transport operators and other relevant stakeholders, as well as the results of similar projects funded from European funds.

It should be noted that although the research covered a wide range of documents and sources, the multitude of indirect effects generated by the unpredictability of transport on the Danube such as abandoning investment decisions or developing new transport routes are difficult to quantify, even if the analyzed information clearly highlights the existence of such situations.

6.2 Studies and analyses on navigation conditions on the Danube

Aspects of inland navigation conditions have been addressed in a number of studies and analyses, some of which have been carried out over relevant periods of time, with a view to presenting the effects of not ensuring depth from different perspectives.

Regardless of the approach chosen, all these analyses have shown a significant negative impact on shipping companies and the potential for developing the importance of inland waterway transport in logistics chains.

It should be noted that due to the multiple categories of data involved (depth, weather conditions, hydrological data, flows of goods, economic data, situations of disruption of the general economic framework such as financial or health crises, etc.) the approach used this empirical method to highlight each time relevant aspects on the approached subject, but not a complete evaluation of the effects.

Below are the main documents and analyses related to the navigation conditions on the Danube, made recently, which were taken into account in order to prepare this output.

- ***Inventory of the Most Important Bottlenecks and Missing Links in the E Waterway Network*** Resolution No. 49; Revision 1; United Nations, 2013 (UN, 2013)

The European Agreement on Main Inland Waterways of International Importance (AGN) in its Annex I establishes the E waterway network including several portions that do not currently exist and are considered missing links.

In its Annex III, the Agreement sets out: requirements for the classification of category E waterways. In total, 29,131 km of European inland waterways have been established by governments as type E waterways. The value of the above excludes the length of the sections on which two or several E waterways overlap.

According to the AGN Agreement, only waterways that meet the basic criteria for the minimum requirements of Class IV (minimum ship size: 80.00m x 9.50m) may be considered E-type waterways. The Agreement recommends that the following new waterways to be built (to fill in missing links) should meet at least the requirements of class Vb, while the waterways to be upgraded should meet the requirements of at least class Va.

- Backalic, T.; Maslaric, M., ***Navigation conditions and the risk management in inland waterway transport on the middle Danube***; Transport Problems; Vol. 7, Issue 4, 2012 (Backalic & Maslaric, 2012)

The development of inland waterway transport depends directly on the operating characteristics of the inland waterway network. The analysis of the navigation conditions of inland waterways is always done before building ships or carrying out a transport program.

It is known that the draft of the ship is usually the limit value for transport capacity and that it depends on the depth of the waterway or in certain ports. This is the reason why the characteristics of inland navigation are known as precisely as possible, especially from this point of view.

The article highlights the importance of understanding the risks associated with inland navigation limitations due to the lack of depth required. Climate change issues are being considered, which could increase concerns about ensuring water levels.

The analysis was made on the changes in the water level in the Middle Danube in the last sixty years.

- Anja Scholten, Benno Rothstein, *Navigation on the Danube - Limitations by low water levels and their impacts*, JRC, Technical Reports, European Commission, 2016[2] (Anja Scholten, 2016)

The technical report presents an expert analysis, including some key messages:

- the Danube river has blockages where the transport is significantly affected by the water level;

- rail transport is an important competitor for IWT; the increase in the cost of shipping leads to the transfer of goods to rail transport;

- the data show a clear, albeit complex, link between water levels and transport prices;

- some estimates can be made of the impact of water levels on the total volume of goods transported, on the utilization of available transport capacity and other related issues;

- the analysis shows that these impacts are considerable. For example, for every 10 cm drop in water level in one location, capacity utilization is reduced by an average of 0.6%, which means a reduction in capacity of about 1,700 t or more;

- there are options that can limit the impact of low water levels on navigation. These include the development of a fleet with smaller vessels (less affected by low water levels), hydrotechnical works and constructions for the rehabilitation and maintenance of the fairway.

- van Dorsser, C.; Vinke, F.; Hekkenberg, R.; van Koningsveld, M., ***The effect of low water on loading capacity of inland ships,*** The European Journal of Transport and Infrastructure Research, ISSN: 1567-7141, Issue 20(3), 2020, pp. 47-70[3] (van Dorsser, Vinke, Hekkenberg, & van Koningsveld, 2020)

The article shows that prolonged periods of drought affect inland navigation, causing the level of water and the depth of water available for long periods of time to decrease.

The shallow depth of the water has a major impact on the carrying capacity of inland waterway vessels and, as a consequence, on the carrying capacity of the general water supply chain.

[2] *https://publications.jrc.ec.europa.eu*

[3] *https://doi.org/10.18757/ejtir.2020.20.3.3981*

Ship-owners need to reduce the draft of their vessels and the weight of the goods carried in order to adapt to the situation. These parameters are even adjusted according to the environmental circumstances (for example, the nature of the river bed) and the type of cargo.

Based on a series of field observations and information collected from ships, the article introduces a model to define the effect of low water constraints on ship cargo, based on the type and characteristics of ships.

The need for such a model is important for the design and operation of transport chains, on the one hand, and for optimizing channel maintenance and the development of long-term infrastructure, on the other.

The data defining the constructive characteristics of the ships analyzed in the article are included in the table below.

Table 2 Characteristics of the analyzed vessels to determine the effect of low water on load capacity

Operational conditions		**Deep water design draft**			**Minimum operational draft**		
CEMT Class	Ship dimensions	Draft [m]	DWT [tonnes]	Payload [tonnes]	Draft [m]	DWT [tonnes]	Payload [tonnes]
			Tankers (double hull)				
Class IV	85 x 9.50 m	2.77	1316	1237	1.30	247	194
Class V	110 x 11.40 m	3.50	2849	2679	1.40	432	318
Class VI+	135 x 17.50 m	5.02	8759	8233	1.50	955	604
			Dry bulk ships (single hull)				
Class II	55 x 6.00 m	2.41	537	505	1.20	176	155
Class III	80 x 8.20 m	2.67	1202	1130	1.20	309	261
Class IV	85 x 9.50 m	2.88	1612	1516	1.30	422	358
Class V	110 x 11.40 m	3.44	3125	2937	1.40	710	585
			Dry bulk ships (double hull)				
Class IV	85 x 9.50 m	2.88	1521	1429	1.30	340	279
Class V	110 x 11.40 m	3.44	2982	2803	1.40	588	469

Class VI	135 x 11.40 m	3.62	3944	3707	1.50	874	716
Containerships (double hull)							
Class III	63 x 7.00 m	2.78	802	754	1.20	162	130
Class IV	85 x 9.50 m	3.16	1713	1610	1.30	318	250
Class V	110 x 11.45 m	3.50	3066	2882	1.40	584	461
Class VI	135 x 14.25 m	3.93	5499	5169	1.50	1083	863
Class VI+	135 x 17.50 m	4.22	7307	6878	1.50	1238	945
Dumb barges							
Class IV	70 x 9.50 m	3.19	1649	1649	1.30	472	472
Class V	77 x 11.40 m	3.98	2763	2763	1.40	604	604
Class V	90 x 11.40 m	4.11	3370	3370	1.40	716	716

6.3 Loss Analysis

An analysis of events reported by administrations, ship-owners or other relevant stakeholders shows that situations occur periodically when navigation is restricted due to shallow depths or is stopped because the lowered water level does not allow a critical point to be passed or other events such as are freezing phenomena or navigation incidents.

Reports include many situations when convoys had to be dismantled and barges had to cross the critical point in turn, with additional costs and delays being incurred.

Annexes 1 and 2 include data on a series of reference data on transport time against which calculations can be made to identify losses of shipping companies.

7 User guide for Fairway maintenance impact calculation tool

7.1 General aspects of navigation on the Danube

In order to make assessments of the economic losses associated with situations where navigation is affected due to lack of recommended depths or other incidents affecting the waterway, a number of input elements such as navigability issues on different sectors of the Danube may be considered. (Table 3)

Table 3 Nautical characteristics of the different Danube sections
(Source: Manual on Danube Navigation, 2014, developed as part of the IRIS Europe 3 Project, quotes via donau, Danube Commission (IRIS, 2014))

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

Other elements such as the number and characteristics of locks on the navigation route should also be taken into account when analysing the duration of voyages and the limitations of navigation on the Danube.

Shipping companies also analyze the schedule and operation of these locks, as these issues could lead to changes in the duration of the journey for the established route.

Table 4 shows the number of locks for different sections of the Danube, as well as their characteristics (Anja Scholten, 2016).

Navigation on the Danube also includes limitations on the number of barges included in pushed convoys (Table 5) (Anja Scholten, 2016).

Table 4 Lock sizes in the named area of the river

Area of the locks	*Danube kilometre*	*length (m) of the locks*	*width (m) of the locks*	*depth (m) of the locks*
Kehlheim- Regensburg	2414.7-2379.0	190	12	4
Regensburg – Wien	2379.0-1920.3	230	24	4
Wien – Gönyü	1920.3-1791.0	230	24	4.5
Gönyü – Budapest	1791.0-1646.5	260-310	34	4.5
Budapest – Braila	1646.5-170	310	34	4.5

Table 5 Number of barges allowed to push in the named area of the river (Source: Danube Commission)

Area	*Length of river stretch (km)*	*Number of barges allowed*
Kehlheim- Regensburg	32	2
Regensburg – Devin	500	4
Devin – Estuar Sava	704	6
Estuar Sava – Sulina	1175	9

7.2 Determination of the depth level in the calculation of the cargo quantity limitation on board

In order to determine the influence of the water level on the economic losses of the shipping company, data extracted from the tonnage certificates of ships / barges provided by shipowners or taken from other cited publications are used.

This is where the values of the displacement corresponding to the different draft levels are taken form, and the difference in the amount of cargo that could have been loaded is calculated between the full load draft and the one given by the water level.

It should be noted that the lowest water level in the navigation route to be followed by the vessel should not be entered in the data for performing the calculations without lowering the safety level below the keel (UKC).

This level is defined by the authorities depending on the nature of the riverbed (gravel, rock), but also on the type of ship. Thus, for example in Germany the UKC is 20 cm for gravel and 40 cm for rocky bed. Differences are shown between tankers (double-hull), which have an increased risk of pollution in the event of an accident, and other types of ships (single-hull).

The behaviour of the ship during the voyage (dynamic stability) must also be taken into account, which implies taking into account the hold of the ship, which will have a variation given by the cross section of the river and the speed of the ship. (Figure 3)

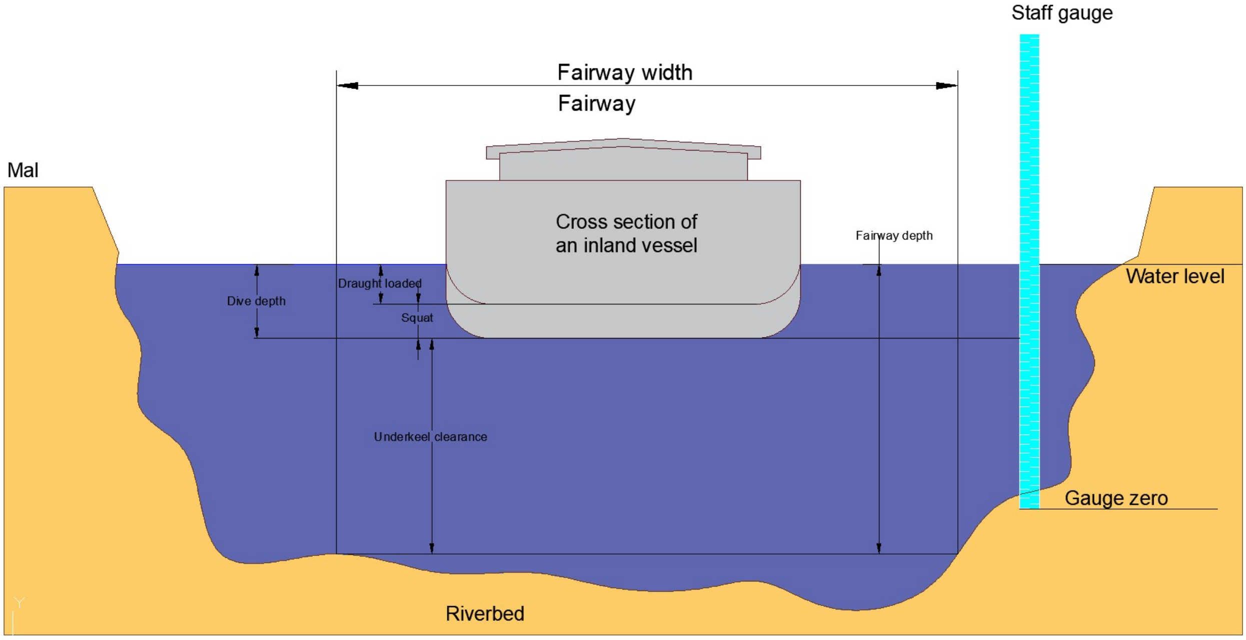


Figure 3 The parameters of the channel taken into account when calculating the draft
(Source: Manual on Danube Navigation, 2014, developed as part of the IRIS Europe 3 Project, quotes via Donau, Danube Commission (IRIS, 2014))

Increased attention is needed to the water depth and underkeel clearance for dangerous goods transport and special transport.

7.3 Types of calculations performed by the application

The Fairway maintenance impact calculation tool application performs three types of calculations to highlight economic loss generated by the insecurity of the depths recommended by the Danube Commission, as well as other situations that may generate blockages (frost phenomena, accidents etc.).

The application is based on data taken from ship / barge documents as well as analyses made during the output of the Dionysus project work package, which can be supplemented with other types of ships that were not included and with updated data, taking into account the variation of the costs generated by the demand-supply, the price of fuels, the labor costs, etc.

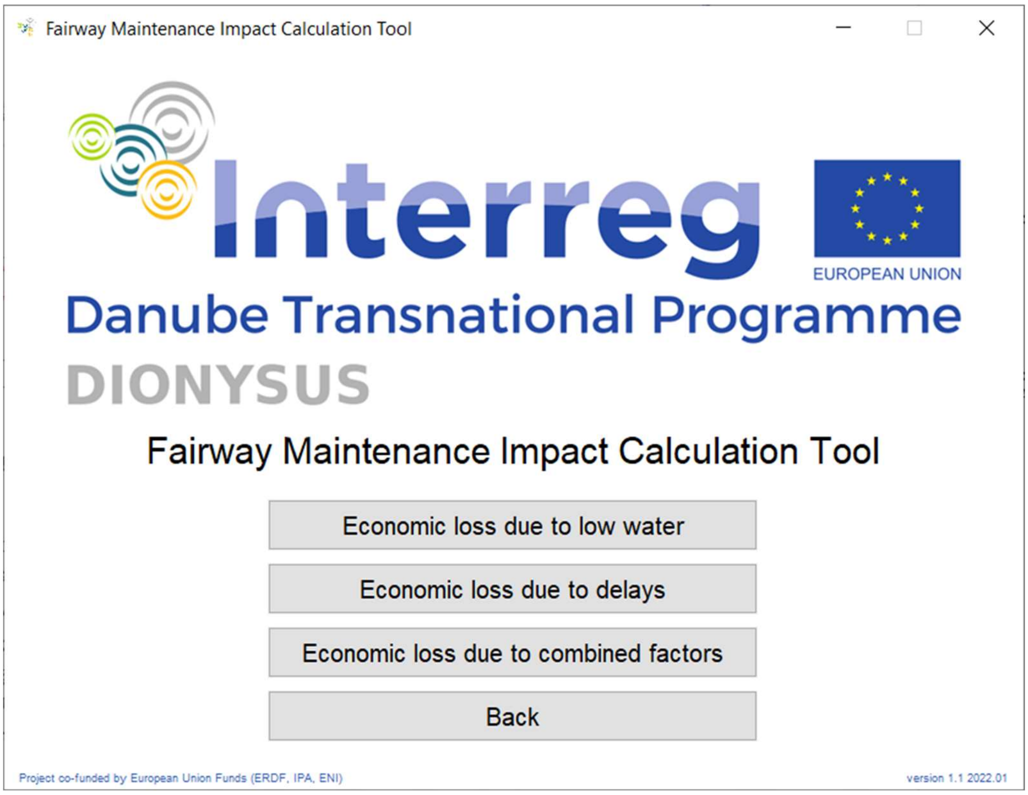


Figure 4 Types of evaluations performed with the "Fairway maintenance impact calculation tool" application

System requirements

To run the application, it is needed Windows operating system and the Java Runtime Environment program, which, if not installed, can be downloaded from www.java.com. Fields are explained in tooltips. Hover mouse cursor over field to view tooltip.

For each type of calculation, the application generates an Excel file that includes the input and output data in order to create a database with all the data processed by each user. The file is ".csv" type and to process this data it is necessary to save it ("save as") in ".xlsx" format which allows the use of all Excel functions necessary for further analysis. The application uses characters from different languages (ro / bg) and if the version of Excel you are using does not interpret the special characters correctly, you can watch this tutorial: https://answers.microsoft.com/en-us/msoffice/forum/all/how-to-open-utf-8-csv-file-in-excel-without-mis/1eb15700-d235-441e-8b99-db10fafff3c2

7.3.1 Calculation of economic loss due to low water level

In order to calculate the losses due to the low water level, the limit quantity that can be loaded due to the lowest depth at the critical point is compared with the loading capacity of the ship / barge / convoy.

The application uses data extracted from tonnage certificates or provided by shipowners, on draft (in cm) and load capacity (in tonnes) as shown in Table 6 and interpolates for intermediate values.

The assessment can be made for both the maximum draft of the vessel and the value of the depth recommended by the Danube Commission (250 cm), in which case it is necessary to select the UKC specific to the nature of the riverbed and the type of vessel. For the calculation of losses, the values of the freight (in Euro) must be entered.

For calculations already performed with the application, average values for some navigation routes are entered.

How it works

• Data entry

- Select the port of departure from the predefined list. It can be extended with new upload points (by selecting the *other* option);
- Select the port of arrival from the predefined list. It can be extended with new upload points (by selecting the *other* option);
- Enter the date on which the analysis is made (*day-month-year format*);
- Select the type of ship / barge from the predefined list. It can be extended with other ship types (by selecting *new*) than existing ones. For this, it is necessary to extract from the tonnage certificates the displacement for different levels of the draft (for intermediate values, the calculation of the displacement is performed by the application by interpolations);
- Select the type of goods transported. If not specified, it will be completed with a new type by selecting the *other* option;
- Enter the water level at the critical point with the lowest value of the depth;
- Enter the Under Keel Clearance at the critical point with the value as given by the authorities (for example, in Germany the level of 40 cm for rocky bed and 20 cm for gravel bed for ships with double hull) or those established by the company;
- Enter the freight in euro / ton. The value can be entered using decimals;
- For convoys: After entering the port of departure, port of arrival, date, water level and Under Keel Clearance (see above), select the barges in the convoy, entering the number of barges (*ship count*) of a certain type (*ship type* - the list can be extended by selecting

the *new* option), the type of cargo transported (*cargo type* - the list can be extended by selecting the *other* option) and the value of the freight. To enter a number of other barges in the convoy, use the *next* and *"+"* buttons, use the *Delete* button to correct or delete, and use the "*prev*" and "*next*" buttons to view the completed data.

- Generate report
  - ➢ The report includes the input and output elements entered and a warning (*Disclaimer*) to highlight that this type of calculation refers exclusively to the direct economic losses of the transport companies and that the losses on the entire supply chain are not included nor indirect ones generated by producers, end users or those related to the loss of new business or investment.

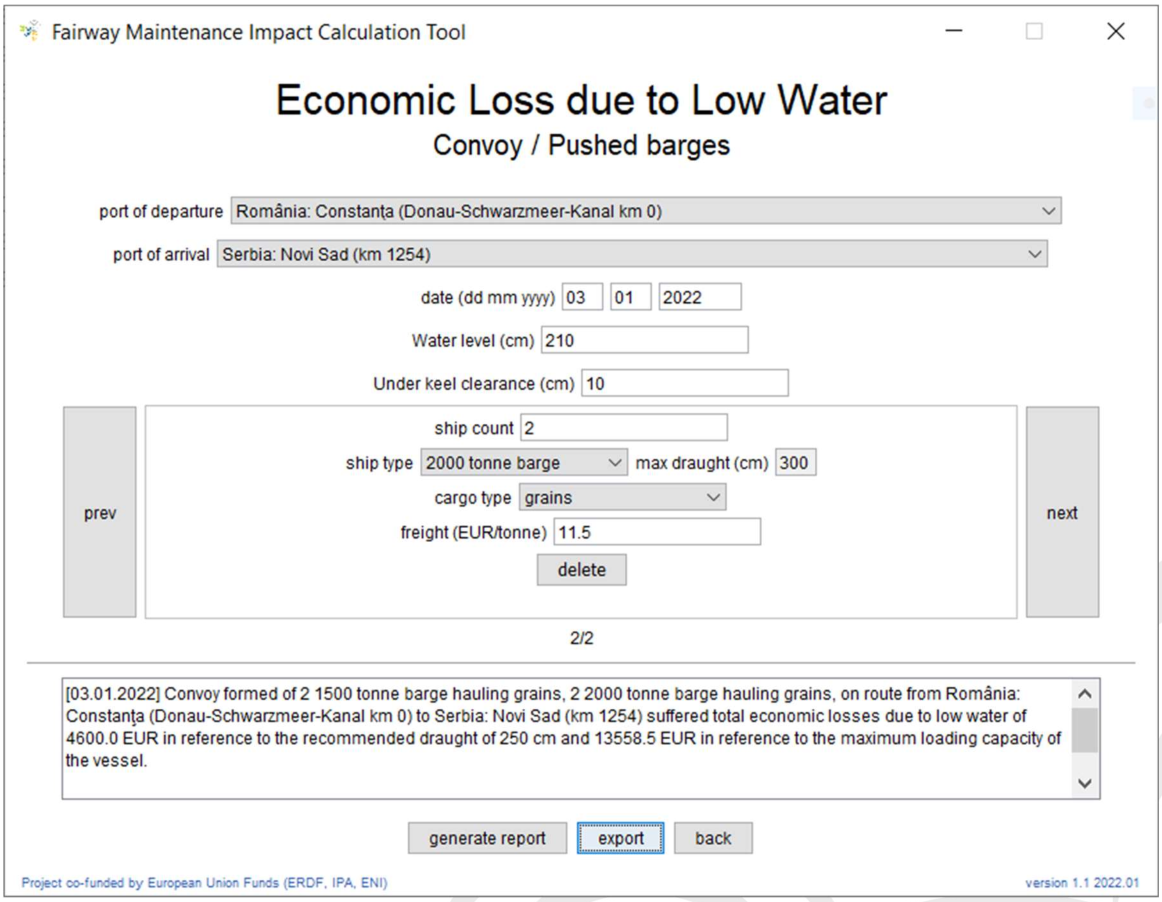


Figure 5 Example of a generated report by the application

- Export data
  - ➢ The Export function is used, the application confirming the successful export of the data.

Table 6 Loading capacities at different drafts
(Source: Navrom)

No.	*Ship type*	*3.8 m*	*3.5 m*	*3.0 m*	*2.7 m*	*2.5 m*	*2.4 m*	*2.33 m*	*2.0 m*	*1.5 m*
1	barge 3000 tonnes (Tmax = 380 cm)	2,900	2,618	2,148	-	1,681	-	-	1,219	763
2	barge 2000 tonnes (Tmax = 300 cm)	-	-	2,000	-	1,600	-	-	1,200	803
3	Barge 1700 tonnes (Tmax = 270 cm)	-	-	-	1,740	1,578	-	-	1,173	775
4	barge 1500 tonnes (Tmax = 250 cm)	-	-	-	-	1,500	-	-	1,121	757
5	barge 1400 tonnes (Tmax = 240 cm)	-	-	-	-	-	1,433	-	1,095	723
6	barge 1000 tonnes (Tmax = 200 cm)	-	-	-	-	-	-	-	1,000	660
7	dumb barge 1100 tone (Tmax = 233 cm)	-	-	-	-	-	-	1,100	902	602

The result shows the economic loss for the self-propelled ship / barge / convoy if it had to load a smaller amount of cargo due to depth limitations. Such assessments may also be made for a number of vessels to analyze the impact of a low depths period for a particular navigation sector.

However, it should be noted that at present no data have been identified in the analyzed history that could provide a clear picture of the number of ships / barges affected this way.

7.3.2 Calculation of economic losses due to delays

Blockage of navigation or delays caused by frost, accidents or very low water levels also have a considerable contribution to the losses generated by shipping companies and the entire supply chain, which includes a river transport component.

Although not highly complex, the component has been developed in order to have a clear picture of the types of influence on losses due to navigation restrictions, but also to be able to calculate losses due to several factors, as well as to be able to assess the impact of an event that led to the blocking of navigation at a certain critical point of the Danube.

In order to make the calculation, the ships / barges / composition of the convoy are selected and taking into account the penalties for delays specified in the contract documents or the daily expenses associated with the ship / barge (in euros / hour) the total losses are obtained.

Results could also be centralized for multiple ships / convoys associated with a period of navigation blockage (as exemplified in the *Report* (AtlasResearch, 2021)).

Collecting and interpreting data using such a tool is likely to give an overview of the losses incurred.

How it works

- Data entry
  - ➢ Enter the time and date of the start of the delay (*hour-minute; day-month-year*);
  - ➢ Select the critical point associated with the delay. The list of critical points is made according to data from the Danube Commission but this can be extended (by selecting the *other* option and manually entering a new critical point);
  - ➢ Select the reason for the delay (*low water, frost, incident*), the list can be extended (*other*);
  - ➢ Enter the value of the penalties (euro / hour);
  - ➢ Enter the duration of the delay (hours-minutes);
  - ➢ For convoys, the convoy is constituted similar to the presentation in subchapter 7.3.1, by entering the number of barges and the value of penalties.

- Generate report
  - ➢ The report includes the input and output elements entered and a warning (Disclaimer) to highlight that this type of calculation refers exclusively to the direct economic losses of the transport companies and that the losses on the entire supply chain are not included, nor indirect ones generated by producers, end users or those related to the loss of new business or investment.

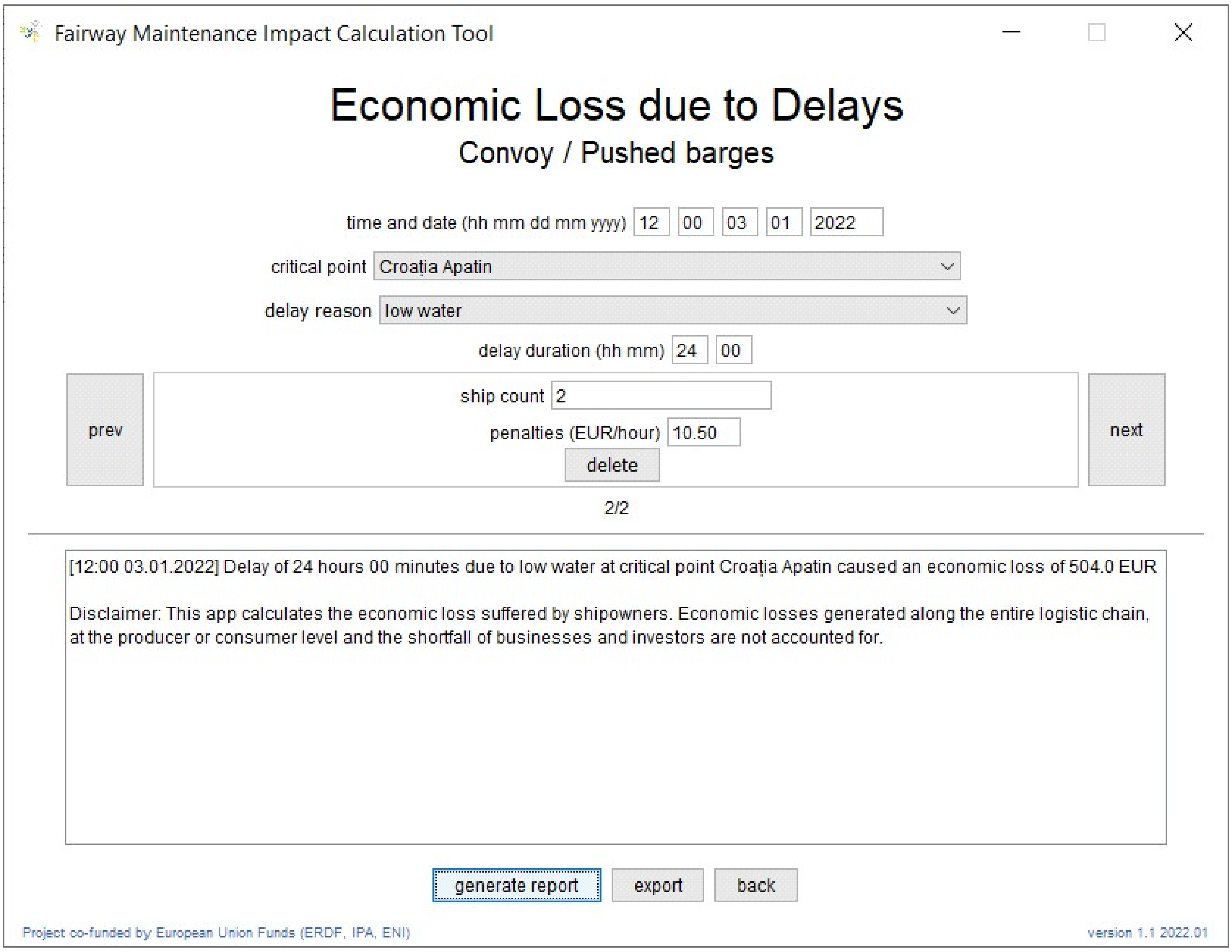


Figure 6 Example of a generated report by the application

- Export data
  - The Export function is used, the application confirming the successful export of the data.

7.3.3 Calculation of economic losses due to the sum of several factors

The *Fairway maintenance impact report* (AtlasResearch, 2021) presents a history where long periods can be highlighted in which the Danube had shallow depths, sometimes so limited that it was necessary to stop navigation.

In all these situations, both types of losses occur for shipping companies, both due to loading with limited quantities of goods, and waiting periods or delays due to the passage of barges in turn at critical points.

Another phenomenon of delay sometimes occurs when the waters are low, so in order to reach Cernavoda ships / barges must sail downstream on Borcea to Hârșova and then sail upstream on the Danube to Cernavoda.

This time, in addition to the delays, there are additional fuel costs.

In calculating the losses generated by several factors, the user will select from the database the type of ship, critical point, etc., as shown in 7.3.1 and 7.3.2 and will obtain the cumulative amount of losses.

How it works

- Data entry
  - ➢ Select the port of departure from the predefined list. It can be extended with new ports (by selecting the *other* option);
  - ➢ Select the port of arrival from the predefined list. It can be extended with new ports (by selecting the *other* option);
  - ➢ Enter the date on which the analysis is made (*day-month-year* format);
  - ➢ Select the type of ship / barge from the predefined list. It can be extended with other ship types (by selecting *new*) than existing ones. For this, it is necessary to extract from the tonnage certificates the displacement for different levels of the draft (for intermediate values, the calculation of the displacement is performed by the application by interpolations);
  - ➢ Select the type of goods transported. If not specified, it will be completed with a new type by selecting the *other* option;
  - ➢ The water level is introduced at the critical point with the lowest value of the depth;
  - ➢ Enter the Under Keel Clearance;
  - ➢ Select the reason for the delay;
  - ➢ Enter the time of the start of the delay (hour-minute);
  - ➢ Enter the freight in euro / ton. The value can be entered using decimals;
  - ➢ Enter the value of the penalties (euro / hour);
  - ➢ For convoys, the convoy is similar to the previous subchapters by entering the number of barges and the value of penalties and selecting the type of barge and the transported goods. To enter a number of other barges in the convoy, use the next and "+" buttons, use the d*elete* button to correct or delete, and use the "*prev*" and "*next*" buttons to view the completed data.

- Generate Report
  - ➢ The report includes the input and output elements entered and a warning (Disclaimer) to highlight that this type of calculation refers exclusively to the direct

economic losses of the transport companies and that the losses on the entire supply chain are not included, nor indirect ones generated by producers, end users or those related to the loss of new business or investment.

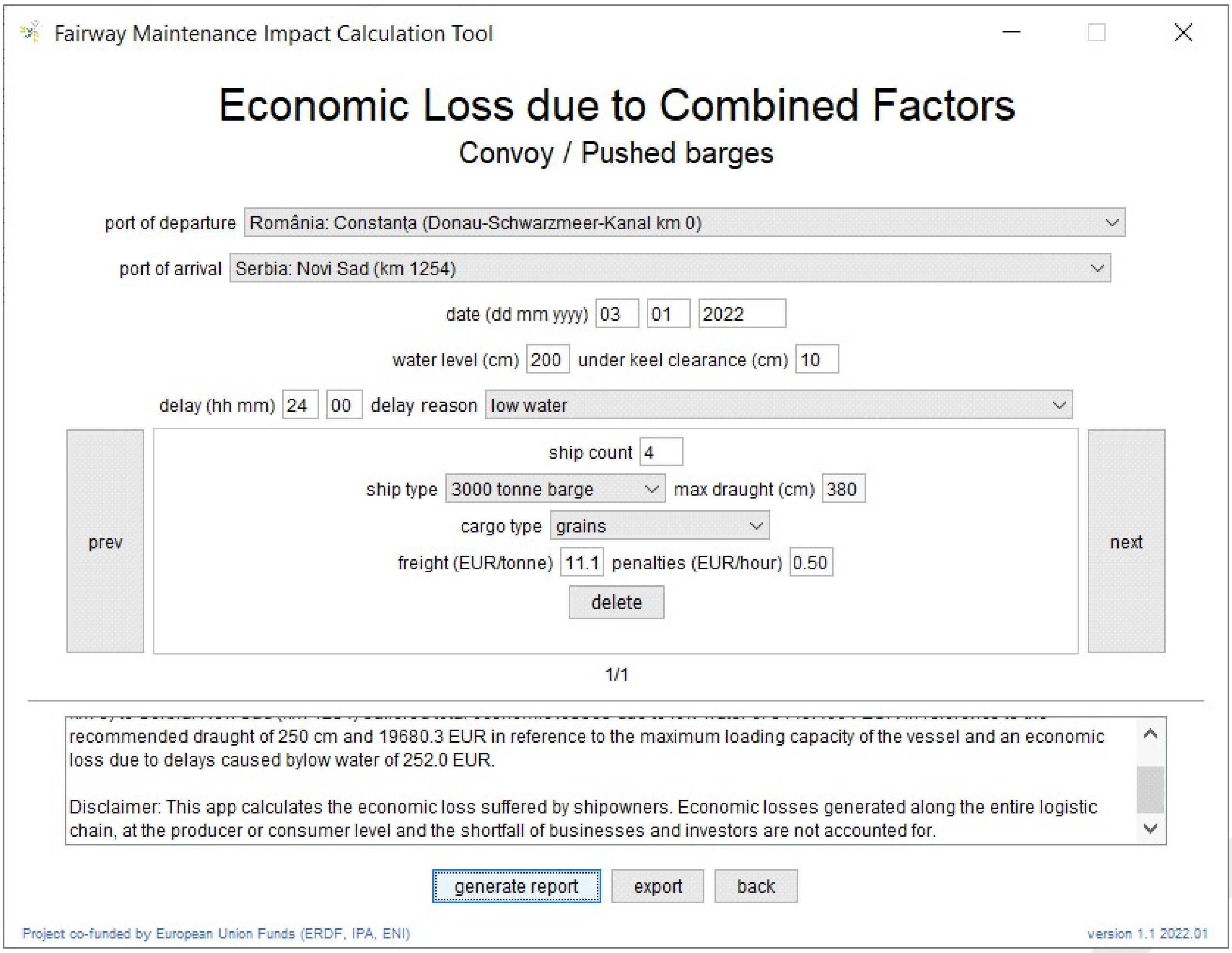


Figure 7 Example of a generated report by the application

- Data export
  - ➢ The Export function is used, the application confirming the successful export of the data.

8 References

A.P.M. (2021). *Caiet de sarcini T1.2 Instrument de calcul al impactului întreținerii șenalului navigabil, Proiect Dyonisus DTP3-576-3.1, Programul Transnațional dunărea 2014-2020.* Constanța.

Anja Scholten, B. R. (2016). *Navigation on the Danube - Limitations by low water levels and their impacts.* European Commission, JRC, Technical Reports.

APDM. (2020). Retrieved from "Platforma Multimodală Galați - Etapa I - Modernizarea infrastructurii portuare": https://www.romanian-ports.ro/site_PMG/pmg_ro.php

AtlasResearch. (2021). *Raport de impact asupra întreținerii șenalului navigabil.* Proiect "Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chain – DIONYSUS".

Backalic, T., & Maslaric, M. (2012). *Navigation conditions and the risk management in inland waterway transport on the middle Danube.* Transport Problems; Vol. 7, Issue 4.

CE-Deflt. (2019). Overview of transport infrastructure expenditures and costs. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1

CE-Deflt. (2019a). *Overview of transport infrastructure expenditures and costs.* Retrieved from https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1

CE-Delft. (2019). *Handbook on the external costs of transport.* Retrieved from https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1

CE-Delft. (2019). *Sustainable transport infrastructure charging and internalisation of transport externalities: Executive summary.*

CE-Delft. (2019). Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities: Main Findings. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/e0bf9e5d-a386-11e9-9d01-01aa75ed71a1/language-en/format-PDF/source-184067569

CEMT. (1992). Retrieved from Resolution of the European Conference of Ministers of Transport (CEMT) No. 92/2 : https://inspire.ec.europa.eu/enumeration/CEMTClassValue

COMCEC. (2015). Retrieved from http://www.comcec.org/wp-content/uploads/2015/12/5-Transport-Report.pdf

DailyNewsHungary. (2021). Retrieved from The largest intermodal railway terminal in Europe is being built on the New Silk Road in Hungary: https://dailynewshungary.com/the-largest-intermodal-railway-terminal-in-europe-is-being-built-on-the-new-silk-road-in-hungary-video/

Danube Commission. (2021-2015). *Market Observation for Danube Navigation.* Budapest: Accesat la: www.danubecommission.org.

Delft-C. (2019). Retrieved from MI0518052ENN.en.pdf: https://op.europa.eu/en/publication-detail/-/publication/7ab899d1-a45e-11e9-9d01-01aa75ed71a1

DPN. (2017-2019). Retrieved from DAPHNE: http://www.interreg-danube.eu/approved-projects/daphne

EBRD. (2013). Retrieved from Sue Barrett, EBRD Director for Transport.: https://www.ebrd.com/news/2013/ebrd-supports-modernisation-of-port-infrastructure-in-moldova.html

EC. (2006). *Commission Regulation (EC) No 851/2006 of 9 June 2006 specifying the items to be included under the various headings in the forms of accounts shown in Annex I to Council Regulation (EEC) No 1108/70.* Retrieved from https://eur-lex.europa.eu/eli/reg/2006/851/oj

ECORYS. (2005). Retrieved from Infrastructure expenditures and costs : https://ec.europa.eu/transport/sites/transport/files/themes/infrastructure/studies/doc/2005_11_30_guidelines_infrastructure_report_en.pdf

Egis International, D. C. (2013). Logistics Processes and Motorways of the Sea II TRACECA Inland Waterways – Danube Case Study.

ESPO. (2018). *Port Investments Study 2018.* Retrieved from The Infrastructure investment needs and financing challenge of European Ports: https://www.espo.be/media/Port%20Investment%20Study%202018_FINAL_1.pdf

GIFP. (2014). Retrieved from MIXED-GAUGE RAIL TERMINAL: http://gifp.md/en/services-facilities/mixed-gauge-rail-terminal/

GIFP. (2020). Retrieved from http://gifp.md/en/news/first-transshipment-of-scrap-metal-completed-successfully/

Grendel. (2020). *GRENDEL – Green and efficient Danube fleet.* Retrieved from https://navigation.danube-region.eu/grendel-green-and-efficient-danube-fleet/

Guler, N. (2003). Retrieved from Economic evaluation of ports investments: https://www.researchgate.net/publication/44785510_ECONOMIC_EVALUATION_OF_PORT_INVESTMENTS

Hricová, R. (2017). SITUATION ON INTERMODAL TERMINALS IN THE SLOVAK. *Acta Logistica - International Scientific Journal about Logistics, 4*(3), 19-23. doi:10.22306/al.v4i3.51

ILR. (2020). Retrieved from High Performance Green Port Giurgiu - Stage II - Construction: https://www.ilr.com.ro/projects/high-performance-green-port-giurgiu.html

InDanube. (2019). Retrieved from https://indanube.eu/greening-tool/

INEA. (2020). *CEF support to Rhine - Danube Corridor.* Retrieved from https://ec.europa.eu/inea/sites/inea/files/cefpub/cef_transport_2020-corridor-i_rhine-danube_metadata.pdf

INEA, I. a. (2018). CEF support to Rhine - Danube Corridor.

IRIS. (2014). *Manual de navigație pe Dunăre, Proiectul IRIS Europe 3.* via donau, AFDJ.

ITF. (2013). Retrieved from Understanding the value of transport infrastructure: Guidelines for macro-level measurement of spending and assets, Paris: International Transport Forum.

Jovanović, S. &. (2018). Retrieved from Danube Port Development Strategy and Network Formation. Good Practices for Port Master Planning, DAPhNE Project: http://www.interreg-danube.eu/uploads/media/approved_project_public/0001/27/e0c5a827a67

Jovanović, S., & all, A. W. (2017). *Port infrastructure & industrial development.* Retrieved from D.5.1.1: Status of port infrastructure development along the Danube: http://www.interreg-danube.eu/uploads/media/approved_project_public/0001/27/73f53f59745d05389b91577ed0a17ed0f17a6b07.pdf

Khider, M. (2000). Retrieved from A socio-economic appraisal of inland water transport in Sudan: https://www.codesria.org/IMG/pdf/t_el_khider_mohammed_osman-3.pdf?809/2cf840b1b423a4eeeb70a150cc8ed9358dfc94ea

Madin, N. & all. (2014). Retrieved from Madin, N. & all, (2014). Integrated Strategy for Functional Specialization of the Danube Ports in the Logistic Chain, DaHar Project : www.southeast-europe.net/document.cmt?id=758

MAKK. (2007). Retrieved from Socio-economic Considerations with Respect to the Ten-T Development Plans for the Danube: http://awsassets.panda.org/downloads/socioeconomic_considerations_of_tent.pdf

MinFin. (2006.a). Retrieved from Excise Duties and Tax Warehouses Act

MinFin. (2006.b). Retrieved from Regulations for Application of the Excise Duties and Tax Warehouses Act

Nedea, P. (2011). Retrieved from The socio-economic impact generated by the improvement of navigation condition on the Romanian - Bulgarian common sector of the Danube: http://cmu-edu.eu/RePEc/cmc/annals/

Notteboom, T., Pallis, A., & Rodrigue, J.-P. (2021). (N. Y. Forthcoming., Ed.) Retrieved from Port Economics, Management and Policy: https://porteconomicsmanagement.org/

Schroten, A., & all, (. D. (2019). *Sustainable transport infrastructure charging and internalisation of transport externalities.* Retrieved from MI0119418ENN: https://op.europa.eu/en/publication-detail/-/publication/e0bf9e5d-a386-11e9-9d1-01aa75ed71a1

TNO, I. L. (2017). Digital Inland Waterway Area. Luxembourg: Publications Office of the European Union.

UN. (2013). *Inventory of Most Important Bottlenecks and Missing Links in the E Waterway Network.* United Nations Resolution No.49; Revision 1.

van Dorsser, C., Vinke, F., Hekkenberg, R., & van Koningsveld, M. (2020). *The effect of low water on loading capacity of inland ships.* The European Journal of Transport and Infrastructure Research, ISSN: 1567-7141, Issue 20(3).

9 Annex 1 Table of travel times from / to Galați

Direction

Travel time in hours							Travel time in hours			
8 units loaded downstream	6 units loaded downstream	4 units loaded downstream	2 units loaded downstream	Distance in kilometers from the port of Galati	Port	Number of locks	2 units loaded upstream	4 units loaded upstream	6 units loaded upstream	8 units loaded upstream
			201	2265	Kelheim	17	295			
			197	2229	Regensburg	15	290			
			188	2135	Deggendorf	13	277			
		172	148	1962	Enns	9	254	335		
		167	144	1909	Ybbs	7	246	26		
		161	139	1848	Krems	6	238	315		
		155	133	1779	Viena	3	229	303		
		149	129	1718	Bratislava	3	221	292		
154	154	129	111	1490	Budapesta	2	154	191	217	253
138	138	115	99	1329	Baja	2	138	171	194	226
123	123	84	84	1185	Vukovar	2	123	153	174	202
97	83	78	66	1104	Novisad	2	115	143	143	162
90	77	73	61	1020	Belgrad	2	107	132	132	150
53	46	43	36	640	Vidin	0	64	80	116	116
30	25	23	19	343	Giurgiu	0	38	46	53	57
13	13	10	10	150	Cernavodă	0	17	21	23	25

					Galați					
2	2	2	2	22	Reni	0	2	2	3	3
4	4	4	3	47	Isaccea	0	5	5	6	6
	9	7	7	93	Izmail	0	9	12	13	
	14	12	10	139	Chilia	0	14	17	20	
		7	6	79	Tulcea	0	8	11		
			12	150	Sulina	0	15			
	28	21	21	216	Constanța	2	28	32	39	

(Source: Manual on Danube Navigation, 2014, developed as part of the IRIS Europe 3 Project, quotes Navrom (IRIS, 2014))

10 Annex 2 Table of travel times from / to Linz

Direction

Travel time in hours							Travel time in hours			
4 – unit pushed convoy	2 – unit pushed convoy	Motor cargo vessel 2000 tons	Motor cargo vessel 1350 tons	Distance in km	Port	Number of locks	Motor cargo vessel 1350 tons	Motor cargo vessel 2000 tons	2 – unit pushed convoy	4 – unit pushed convoy
	174	161	172	1454	Ghent	62	159	149	165	
	170	157	168	1419	Antwerp	61	115	145	161	
	163	151	160	1325	Amsterdam	61	149	140	154	
	163	151	161	1336	Rotterdam	58	147	138	152	
	145	135	142	1119	Duisburg	58	135	127	141	
	119	113	113	835	Mainz	58	119	111	125	
	115	109	109	808	Frankfurt	56	116	108	122	
	43	41	41	380	Nürnberg	17	55	47	55	
	26	25	25	280	Kelheim	8	39	31	39	
	23	22	22	242	Regensburg	6	33	26	34	
	14	13	13	153	Deggendorf	4	21	17	21	
				0	Linz	0				
2	2	2	2	19	Enns	1	3	2	3	3
7	6	6	6	73	Ybbs	3	10	8	10	11
13	10	10	10	133	Krems	4	17	14	17	19
20	17	17	17	211	Vienna	7	27	22	27	30

26	22	22	22	263	Bratislava	7	36	30	37	41
42	37	37	37	491	Budapest	8	60	51	61	70
51	45	45	45	652	Baja	8	75	63	76	88
61	54	54	54	798	Vukovar	8	90	76	91	106
67	60	60	60	878	Novi Sad	8	99	85	100	117
73	65	65	65	978	Belgrade	8	109	93	110	128
98	88	88	88	1340	Vidin	10	142	120	140	164
115	103	103	103	1639	Giurgiu	10	167	140	163	191
135	121	121	121	2007	Reni	10	197	164	192	224
142	128	128	128	2131	Sulina	10	208	173	201	236
133	120	119	120	1891	Constanța	12	190	159	185	216
139	125	125	125	2074	Izmail	10	203	169	197	231
141	127	127	127	2120	Kilia	10	207	172	200	235

Direction

Source: Manual on Danube Navigation, 2014, developed as part of the IRIS Europe 3 Project, quotes via Donau (IRIS, 2014)

11 Annex 3 List of stakeholders consulted

Company name	Country
National Company Maritime Ports Administration SA Constanta	Romania
Association „Pro Danube Romania" – Association for the promotion of transports on the Danube	Romania
Ministry of Transport, Infrastructure and Communications	Romania
Romanian River Ship Owners and Port Operators Association	Romania
Wiser Consult SRL	Romania
Galati Lower Danube River Administration	Romania
Trading Line Fleet SRL	Romania
Ennshafen Port - Ennshafen OÖ GmbH	Austria
iC consulenten Ziviltechniker Gesmbh	Austria
Pro Danube Management GmbH	Austria
Bulgarian-Romanian Chamber of Commerce and Industry	Bulgaria
Port of Bulmarket	Bulgaria
Public Institution Port Authority Vukovar	Croatia
Hungarian Federation of Danube Ports	Hungary
Fluvius Schifffahrts	Hungary
DDSG Mahart	Hungary
Technical University of Moldova	Republic of Moldova
Port Governance Agency	Serbia
University of Belgrade - Faculty of Transport and Traffic Engineering	Serbia
Public Ports, JSC	Slovakia
State Enterprise "Ukrainian Sea Ports Authority"	Ukraine