PLATINA3
IWT policy platform
- MARKET -

Report on gap analyses on R&D to promote market uptake conditions D1.2

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Executive Summary

The European Green Deal seeks to transform the EU into a modern, resource-efficient, and competitive economy. To reach this ambitious goal, the European Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. In addition, all 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050.

Within the EC's 'Sustainable and Smart Mobility Strategy' the EU has sketched its strategy on how to achieve its green and digital transformation and become more resilient to future crises. The targets defined within this strategy comprise 90% reduction of greenhouse gas emissions in transport by 2050, 55% reduction of emissions from cars by 2030, zero emissions from new cars by 2035, zero emission large aircrafts ready for market by 2035, and transport by inland waterways and short sea shipping will increase by 25% by 2030, and by 50% in 2050.

The European Commission has initiated the NAIADES III action programme to boost future-proof European inland waterway transport. The EU-funded project PLATINA3 project aims to provide the knowledge base for the implementation of this programme towards 2030. Deliverable D1.2 of PLATINA3 is entitled 'Gap analysis on R&D actions to promote optimal market uptake conditions' and focuses on the potential market update of standardised transport units, vessel designs, transhipment infrastructure, and other technical assets. This will eventually enable the access of new types of goods and new markets to inland waterway transport (IWT).

The report provides an overview of new and innovative ideas around inland waterway transport (IWT) in general, and standardised transport units, vessel designs, and transhipment infrastructure more specifically. This inventory is used to analyse the market gaps which must be overcome in order to put such innovations in place and then, eventually, the needs for a market update, potential tools, and incentives are discussed in more detail.

The inventory has shown that there are a couple of trends observable when looking into innovation and development such as i) automation due to increased digitalisation, ICT knowledge, and IoT, ii) alternative fuels to assist in de-carbonisation, iii) electrically driven vehicles especially for shorter distances, iv) alternative transport modes such as magnetic levitation or guided tube concepts, and v) new materials which might assist in reducing construction and maintenance costs, durability, reliability, and speed of constructions. Furthermore, six clusters influencing inland waterway transport (EU policy, new markets, external drivers, enabler, barriers, and innovation) have been identified all of which bring together specific topics which either have an influence on IWT or a bi-lateral relation. These clusters and topics are summarised in a mind map in Figure 4.

Based on this inventory, an analysis of gaps has been performed which resulted in some key gaps/barriers for implementing the upcoming innovations and trends like i) a missing roadmap to modal shift and inter-/multimodal transport, ii) difference in regional boundary conditions (e.g. droughts in the Rhine, missing containers and infrastructure in the Danube, etc.), iii) difference in interests of stakeholders due to 'river focus' (e.g. Rhine or Danube) , EU focus (EU perspective), country focus (national focus), etc., iv) primary focus on costs of transport, v) insufficient financial support, especially for large investments which cannot be carried by the sector alone, vi) lack of legislation and standardisation (for many different topics), vii) lack of workforce skills which have not been adjusted yet to any of the new developments and upcoming trends; and viii) shortage of time to implement all changes if the ambitious EU goals for the sector should be reached according to the envisaged timeline.

In the last part of the report, the focus is on potential measures to trigger market update and to make a modal shift happen. This part is based on the inventory performed and gaps identified and suggests

to i) raise awareness of advantages of inland waterway transport by information campaigns; ii) provide tools to calculate the advantage of a shift (business case); iii) provide a scale for 'measuring' advantages of inland waterway transport (costs per tkm, CO_2 and GHG emissions, etc.); iv) provide maps and comparative calculators for transport which allow to either book IWT directly or combine it with different transport modes; v) trigger an agreement on universal loading unit(s) for intermodal transport and to be used across different transport modes and the 'last mile'; and vi) stimulate modal shift by legislative and financial incentives, both national and EU-wide. For the shift to intermodal transport various measures were discussed dealing with loading units, transhipment infrastructure, digitalisation, legislation and standardisation, and re-skilling of workforce.

Any major shift, whether it is towards the use of alternative fuels or batteries, or towards different transport mode concepts will require awareness raising and providing easily accessible tools which provide more information and reasons for the shift. Some potential tools have therefore been listed, ranging from mapping tools, over cost and business calculation tools, to waterway information (RIS) tools and smart mobility tools. Eventually, financial, legislative, and policy incentives have been briefly discussed to foster the necessary mind shift in order to reach the objectives of the Green Deal and Single Market.

List of abbreviations

AIS	Automatic Identification System
B2G	business-to-government
CEMT	Conférence Européenne des Ministres des Transports (English: European Conference of Ministers of Transport), used as classification of European inland waterways
CESNI	Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure
CH_4	Methane
CO_2	Carbon dioxide
CLINSH	Clean Inland Shipping
CNG	Compressed Natural Gas
Covadem	Collaborative Waterdepth Measurements
EC	European Commission
EIBIP	European Inland Barging Innovation Platform
EN590	European Standard (EN) for ultra-low sulphur diesel
DG	MOVE Directorate-General for Mobility and Transport
DINA	Digital Inland Waterway Area
DMN	Digital Multimodal Nodes
DME	Dimethyl Ether
DPF	Diesel Particulate Filter
DTLF	Digital Transport & Logistics Forum
EGR	Exhaust gas recirculation
ESD	Emergency Shutdown
ESI	Environmental Ship Index
ETA	Estimated time of arrival
FAME	Fatty-acid methyl ester
FWE	Fuel Water Emulsion
GA	Grant Agreement
GHG	Greenhouse gas(es)
GTL	Gas-To-Liquid
HEU	Horizon Europe
HVO	Hydro-treated Vegetable Oil
ICE	Internal combustion engine
IWT	Inland Waterway Transport
LNG	Liquefied Natural Gas
MECA	Manufacturers of Emission Controls Association
NO_x	Nitrous oxide
PLATINA II	Platform for the Implementation of NAIADES II
PM	Particulate matter - microscopic particles of solid or liquid matter suspended in the air

PROMINENT	Promoting Innovation in the Inland Waterways Transport Sector
RIS	River Information Services
SCR	Selective Catalytic Reduction
STU	Standardised Transport Unit
Tkm	Tonne-kilometre
ZEWT cPP	The Co-Programmed Partnership on Zero-Emission Waterborne Transport

1 Introduction

1.1 Background

Transport has a direct effect on the lives of European citizens and is an important strategic element of the European economy. The European Single Market which promotes economic growth, social well-being and increased competitiveness builds to a large extent upon transport and logistics.

On the other hand, it is widely accepted that transport harms the environment, e.g. due to its significant environmental footprint. The transportation sector today still is a major source for greenhouse gas emissions, and therefore contributes to global warming and noise pollution. The sector is characterized by increasing energy prices and by consumption of non-renewable resources.

The balance therefore needs to be in between a further increase of transport activities and at the same time a decrease of its environmental footprint. Inland waterway transport (IWT) has already been identified to have the potential as a competitive alternative and an effective addition to rail, road, and air transport. It is at the same time a sustainable, environmentally friendly, and the most economical mode of transport.

The following sections try to identify the latest (environmental, geo-political, and economic) boundary conditions for the years to come. The underlying strategies have and will continue to have a significant impact on transport in general and IWT specifically. It would be impossible to discuss any future developments within the sector without setting the scene and providing a minimum amount of detail with respect to the key boundary conditions.

1.1.1 European Green Deal

Climate change and environmental degradation are an existential threat to Europe and the world. The European Green Deal seeks to transform the EU into a modern, resource-efficient, and competitive economy, ensuring[1]:

- no net emissions of greenhouse gases by 2050;
- economic growth decoupled from resource use;
- no person and no place left behind.

The European Commission adopted a set of proposals to make the EU's climate, energy, transport, and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. All 27 EU Member States committed to turning the EU into the first climate neutral continent by 2050.

This will create new opportunities for innovation and investment and jobs, as well as:

- reduce emissions;
- create jobs and growth;
- address energy poverty;
- reduce external energy dependency;
- improve our health and wellbeing.

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

1.1.2 Sustainable and Smart Mobility Strategy

In December 2020, the European Commission presented its 'Sustainable and Smart Mobility Strategy' together with an Action Plan of 82 initiatives that will guide its work for the next four years. This strategy laid the foundation for how the EU transport system can achieve its green and digital transformation and become more resilient to future crises. The following targets within this strategy have been proposed[2,3]:

- 90% reduction of greenhouse gas emissions in transport by 2050;
- 55% reduction of emissions from cars by 2030;
- 50% reduction of emissions from vans by 2030;
- Zero emissions from new cars by 2035;
- By 2030, there will be at least 30 million zero-emissions cars and 80 000 zero-emission lorries in operation;
- By 2030, there will be at least 100 climate-neutral cities in Europe. Scheduled collective travel under 500 km should be carbon neutral by 2030 within the EU;
- Zero-emission large aircraft will become ready for market by 2035;
- Traffic on high-speed rail will double by 2030. By 2050 rail freight traffic will double;
- **Transport by inland waterways and short sea shipping will increase by 25% by 2030, and by 50% in 2050**;
- **By 2050, a fully operational, multimodal Trans-European Transport Network for sustainable and smart transport with high-speed connectivity**.

1.1.3 Inland Waterway Transport

For inland waterway transport (IWT), EU Transport Commissioner Adina Vălean (in her keynote speech at the Virtual Ministerial Conference entitled "Inland Waterway Transport: Key to the Green Deal") mentioned the following targets and initiatives for IWT[4]:

- Financial support to IWT via Next Generation EU funds;
- **Shift of EU freight from road and rail to IWT by increasing its capacity, make the sector fit for the future, and to increase its role in the EU's Single Market;**
- Measures could be e.g. fewer barriers, better cross-border traffic, and wider EU digital and environmental harmonisation;
- Infrastructure which is fit for the future, e.g. multimodal terminals;
- Better integration with other transport modes;
- Increased digitalisation;
- Investment in infrastructure and new fleets both from public and private funds;
- Transition towards zero-emission vessels and decarbonisation of the fleet.

The aforementioned targets and boundary conditions for IWT will be a specific focus of this deliverable when looking into market-specific targets. The following sections will highlight the objectives of this deliverable and its mapping against the PLATINA3 outputs.

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[2] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

[3] European Commission (2020): Sustainable & Smart Mobility Strategy, factsheet, available e.g. at https://ec.europa.eu/commission/presscorner/detail/en/fs_20_2350

[4] https://ec.europa.eu/commission/commissioners/2019-2024/valean/announcements/keynote-speech-virtual-ministerial-conference-inland-waterway-transport-key-green-deal_en

1.2 Objectives

Deliverable D1.2 of PLATINA3 is an output of Task 1.2 (T1.2) dealing with 'Standardised Transport Units (modularity), Transhipping Infrastructure & Vessel Design'. This task is one of the five tasks within Work Package 1 (WP1) of PLATINA3 which focuses on 'Market'.

The key objectives of WP1 are:

- Encourage European competitiveness in logistics and mobility services while striving for supply chain decarbonization;
- Support the further integration of inland waterway transport (IWT) into smart, synchromodal value chains to increase the efficiency, reliability, and safety of the entire European transport system (decongesting overloaded road and rail networks), while serving an "on-demand" economy. Extra attention will be given to integration in urban networks;
- Monitor actions aiming towards achieving a totally integrated transport system;
- Facilitate know-how transfer to cope with the challenges linked to Europe's new industrial future and circular economy making shipping fit-for-future;
- Promote a cooperative approach between IWT and other transport modes to pool resources, offer integrated solutions;
- Facilitate a further integration of IWT into EU and national policies and initiatives meant to attract higher volumes and thus contribute to a higher modal share;
- Encourage key stakeholders (barge owners, barge operators) to be more pro-active in marketing and sales and facilitate this by an appropriate communication strategy;
- Provide input for the R&D roadmap and the policy roadmap (WP 5).

The key objectives of T1.2 are to provide an overview and a gap analysis on R&D actions (focussing on standardised transport units; for vessel designs, transhipment infrastructure, etc.) to enable the access of new types of goods and new markets to IWT. The overall objective is to find a way on how to increase IWT's market share.

1.3 Mapping deliverable against PLATINA3 outputs

This section seeks to provide a justification of the deliverable's results against PLATINA3's respective outputs. Table 1 shows how the objectives of PLATINA3's Work Package (WP1) and its relevant tasks (T1.2) are met by the work performed leading to this deliverable.

Table 1. Mapping of deliverable against relevant PLATINA3's GA descriptions

Deliverable	
GA Title:	D1.2 'Gap analysis on R&D actions to promote optimal market uptake conditions'
GA Outline:	Report on gap analyses on R&D to promote market uptake conditions: Following the task description, the report includes an overview and analysis of R&D actions to enable the access of new types of goods and new markets to IWT.
Deliverable chapters:	Chapters 3, 4, and 5
Justification:	Chapter 3 summarises a desk study on new concepts, ideas, and innovative solutions with respect to standardised transport units, vessel designs, transhipment infrastructure, and other technical assets. Chapter 4 performs a market gap analysis and discusses what is needed to uptake such ideas, whereas Chapter 5 discusses the boundary conditions and needs to make such a market update happen.
Work Package	
GA Title:	WP1 'Market'
GA Outline:	WP1 will work out measures to increase the market share of IWT by expanding its integration into smart, synchro-modal transport chains reflecting the needs of Europe’ new industrial future, circular economy, and decarbonisation goals. These chains can be national, transnational, and urban or a combination. In this aim, a structured concept for the overall digitalisation of the sector will be proposed. Focus will be laid on interaction with other transport modes, fostering intermodal operability and management while supporting digitalisation and automation. Best practices and ways to improve organisation, marketing, awareness, communication and to reduce barriers to modal shift on the economic, financial, and regulatory level will be identified, and assessed. At the same time but not independently from the above, measures will be worked out to attract other industries than the traditional IWT users, such as city logistics and palletised continental road cargo. WP1 comprises five tasks dealing with different aspects of market as follows: • T1.1: Increased Modal Shift and Decarbonisation • T1.2: Standardised Transport Units (modularity), Transhipping Infrastructure & Vessel design • T1.3: Synchromodal logistics chains • T1.4: Reducing economic/financial barriers to modal shift • T1.5: Policy and regulatory actions encouraging and facilitating the use of IWT
Deliverable chapters:	Chapters 3, 4, and 5

Justification:	The focus of this deliverable is to find options for increasing the market shares of IWT with a focus on innovative ideas on transport units, vessel designs, transhipment infrastructure, and other technical assets. Chapter 3 identifies these ideas, Chapter 4 does an analysis on what is needed to enter the market with such ideas, and Chapter 5 lists the needs of the market to uptake them. This all is in line with the overall objective of WP1 to find larger market shares for IWT.
Tasks	
GA Title:	T1.2 'Standardised Transport Units (modularity), Transhipping Infrastructure & Vessel Design'
GA Outline:	Task partners investigate past and current R&D actions with respect to modularity of transport units, vessel and (port) infrastructure, as enablers for further development of markets, attracting new cargo, and fostering supply chain integration and decarbonisation. Important know-how is collected from previous and ongoing research sources, projects, and initiatives (CORDIS, WATERBORNE, ALICE, REWWAY). Valuable information is collected from selected industry representatives via interviews, bilateral discussions, and on-site visits. Participation at high visibility events (TRA) and to key small events expected. The input collected within this task will feed directly into the R&D Roadmap output of this project and policy recommendations.
Deliverable chapters:	Chapters 3, 4, and 5
Justification:	Chapter 3 collects the know-how from previous and parallel projects and initiatives, chapter 4 will analyse the gaps with respect to the main fields of research (standardised transport units (modularity), vessel designs, and transhipping infrastructure), and chapter 5 will provide ideas on necessary incentives which would then feed into the R&D roadmap of PLATINA3.

1.4 Deliverable structure

The deliverable is structured as follows:

- Chapter 2 discusses relevant definitions which are used within this deliverable;
- Chapter 3 provides an overview of new and innovative ideas dealing with standardised transport units, vessel designs, transhipment infrastructure, and other technical assets using various sources of information such as publications, documents, websites, etc.;
- Chapter 4 lists legislation documents which are relevant for IWT and summarises the key information with respect to this deliverable;
- Chapter 4 uses this inventory and analyses the market gaps which are needed to overcome to put such innovations in place;
- Chapter 5 discusses needs for a market update, potential tools, and incentives;
- Chapter 6 summarises the key findings of this document and provides recommendations.

2 Relevant definitions

According to Eurostat[5] and EC regulation 425/2007[6], the following definitions apply and will be used throughout this deliverable.

- **Navigable inland waterway**: A watercourse, not part of the sea, which by natural or man-made features is suitable for navigation, primarily by inland waterway vessels. This term covers navigable rivers, lakes, canals, and estuaries.
- **IWT vessel**: A floating craft designed for the carriage of goods or public transport of passengers, which navigates predominantly in navigable inland waterways or in waters within, or closely adjacent to, sheltered waters or areas where port regulations apply.
- **Types of vessels**:
  - Self-propelled barge. Any powered inland waterways freight vessel, other than self-propelled tanker barges.
  - Barge not self-propelled. Any unpowered inland waterways freight vessel, other than not self-propelled tanker barges. This category includes towed, pushed and pushed-towed barges.
  - Self-propelled tanker barge. A self-propelled barge intended for the transport of liquids or gases in fixed tanks.
  - Tanker barge not self-propelled. A barge not self-propelled intended for the transport of liquids or gases in fixed tanks.
  - Other goods carrying vessel. Any other known or unknown kind of inland waterways freight vessel intended for carrying goods not defined in the previous categories.
  - Seagoing vessel. A vessel other than those which navigate predominantly in navigable inland waterways or in waters within, or closely adjacent to, sheltered waters or areas where port regulations apply.
- **Cargo transport units (CTU)**: a freight container, swap body, vehicle, cranable trailer or semi-trailer, railway wagon, or any other similar unit, in particular when used in intermodal transport[7].
- **Containers**: A freight container means an article of transport equipment:
  - 1. of a permanent nature and accordingly strong enough to be suitable for repeated use;
  - 2. specially designed to facilitate the carriage of goods by one or more modes of transport, without intermediate reloading;
  - 3. fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another;
  - 4. so designed as to be easy to fill and empty;
  - 5. having a length of 20 feet or more.
  - The size of containers is reported according to four categories:
    - 1) 20 Foot ISO containers (length of 20 feet and width of 8 feet)
    - 2) 40 Foot ISO containers (length of 40 feet and width of 8 feet)
    - 3) ISO containers over 20 feet and under 40 feet in length
    - 4) ISO containers over 40 feet long

[5] https://ec.europa.eu/eurostat/cache/metadata/en/iww_esms.htm
[6] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:103:0026:0039:EN:PDF
[7] https://wiki.unece.org/display/TransportSustainableCTUCode/Chapter+2.+Definitions

In UNECE (2009)[8], the European Code for Inland Waterways, 11 types of vessels are defined (vessel, motorized vessel, floating equipment, ferry-boat, high-speed vessel, passenger vessel, pushed barge, shipborne barge, sailing vessel, small craft, water bike).

It should be noted, however, that these definitions do not always specify all varieties of vessels, e.g. considering the type of load, the size of the vessel, or its propulsion system. A barge, for example, could carry containers or bulk load. Container barges are built in different sizes / classes, and new types of barges are evolving like e.g. the X-barge. All these types are defined as barges, but can be very different regarding their dimensions, emissions, speed, cargo transport, etc.

Based on the aforementioned definitions, **'standardised transport units'** (STUs) are understood in this deliverable as a transport unit which has been internationally standardised. The standardisation does not necessarily mean that there is only one standard available. Examples for STUs are containers as defined above but are not limited to these units alone.

Transhipment (sometimes also trans-shipment or transshipment), according to Eurostat[9], means the unloading of goods from one ship and its loading into another to complete a journey to a further destination, even when the cargo may have to remain ashore some time before its onward journey. Opposite to the Eurostat definition, the term is only used here in case the goods are moved to another ship. If different means of transport are considered, e.g. loading goods from a ship to rail or road, this deliverable will use the term '**transloading**'.

Transhipment infrastructure is understood in this deliverable as the infrastructure needed for transhipment. Different infrastructure installations are used for different types of goods such as bulk, palletized goods, or containers.

Material handling equipment (MHE) is mechanical equipment used for the movement, storage, control, and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption, and disposal.[1] The different types of handling equipment can be classified into four major categories:[2] transport equipment, positioning equipment, unit load formation equipment, and storage equipment (source: Wikipedia). For inland waterways and bulk loads, this comprises pneumatic ship unloaders, agri-vacuum ship unloaders, dry bulk handling equipment, cranes, feeders, etc. For palletised goods typically cranes and forklifts are used, often with special clamps. For other types of goods such as paper rolls, roundwood, wood, or big bags cranes are used with specific spreaders or clamps. Depending on the surface of materials, specific lifting tools such as vacuum lifting equipment can be used.

8 United Nations. Economic Commission for Europe. Inland Transport Committee. (2009). "CEVNI - European Code for Inland Waterways". New York, Geneva, United Nations. ECE/TRANS/SC.3/115/Rev.4, Rev. 4, 92 pp., 10 Annexes.

9 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Transshipment

3 Inventory

This chapters seeks to provide an overview of recent and running activities related to previous and running research and development projects in IWT (section 3.1) by consulting various national and EU databases, publications in scientific literature and conferences (section 3.2), innovative ideas outside of the projects already covered (section **Fout! Verwijzingsbron niet gevonden.**), and other initiatives (section 3.3) around IWT. Since many projects touch upon different aspects of innovation, including which is innovative vessel design, loading units, and infrastructure, the sections try to provide a topic-related overview whereas more details can be found in Annexes of this deliverable.

3.1 Projects and innovative ideas

Previous and running projects have been re-visited to obtain the relevant knowledge gathered from their findings. The outputs are listed according to the nature of the projects' findings, such as innovation, simulation, legislation, recommendations, etc. This inventory focusses on key results and refers to more information either on the projects' websites or in a cited document/publication. Several EU and national databases and platforms were consulted such as TRIMIS[10], CORDIS[11], WATERBORNE[12], ALICE[13], INTERREG[14,15], or BINSMART[16].

The inventory is structured according to the start time of the project where closed projects are already finished (at the end of 2021), and running projects are running parallel to PLATINA3. All projects are sorted according to their start dates.

Annex A contains a very short overview of the projects which would have been too extensive to be listed in the main bulk of the report. A synthetic tabular overview is provided in the text with an indication of the innovation and the topic being investigated.

Annex B, in addition, provides an overview of additional information from working and expert groups, platforms, studies, and further projects in the area or with a clear link to IWT.

Annex C lists innovative ideas from websites, leaflets, or presentations which were or are not yet published in any of the previously mentioned forms. The ideas are briefly summarised and, again, the focus is on the identified or consequent market uptake conditions needed.

There are numerous R&D projects, actions, Interreg and national projects performed in the IWT sector. The list of projects in this overview focusses on European-based projects even though national projects very often also had or have an international / European perspective. The review is focused on developments and research (projects) within the IWT sector itself and not on projects which seek to develop new markets in the future from which IWT can benefit.

A first analysis of the topics which these projects deal with has been performed by counting the number of topics all projects were dealing with. Figure 1 shows this overview for past projects (already terminated) whereas Figure 2 for still running projects. The total number of projects was 26 for past

10 https://trimis.ec.europa.eu/
11 https://cordis.europa.eu/en
12 https://www.waterborne.eu/
13 https://www.etp-logistics.eu/
14 https://www.interregeurope.eu
15 Map of INTERREG regions at https://interreg.eu/
16 https://www.binsmart.de/forschungsvorhaben/

and 24 for still running projects, respectively. The topics covered by these projects were 44 in both cases.

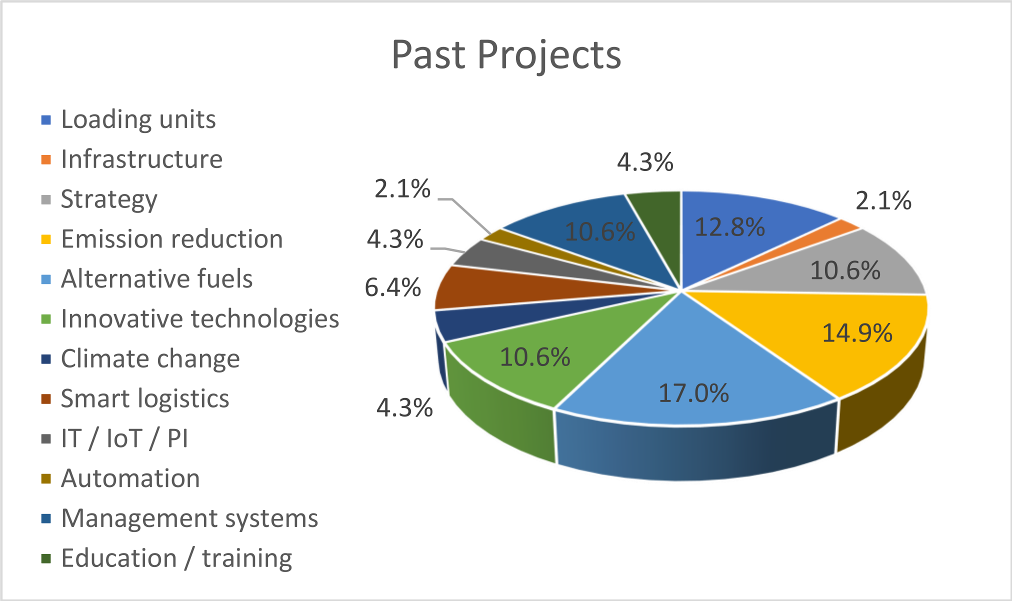

Figure 1. Overview of project topics for past projects (47 topics in total)

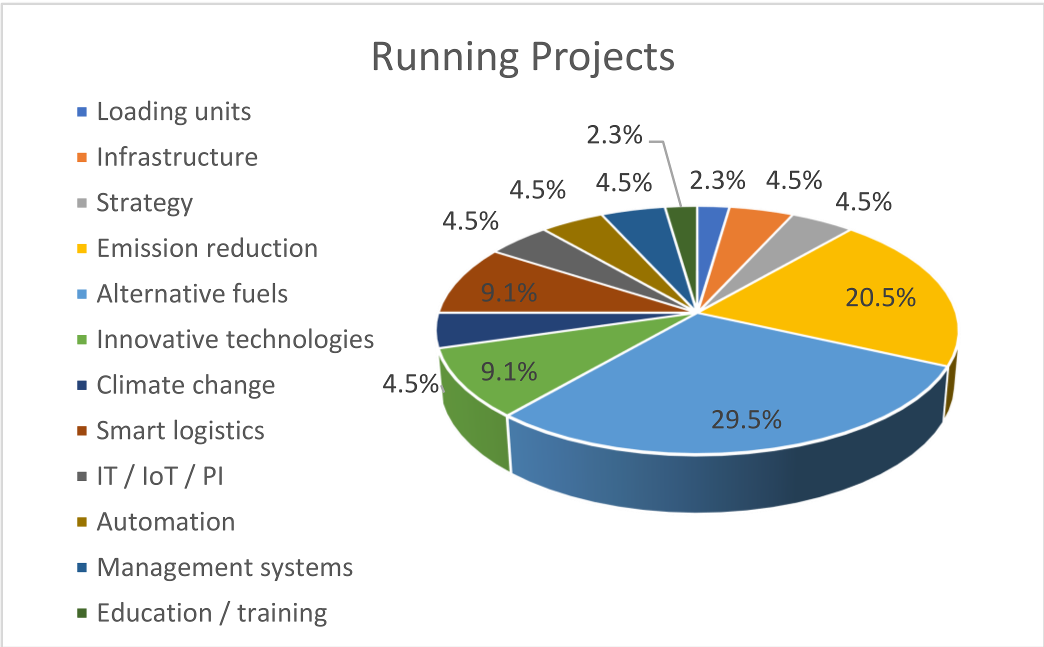

Figure 2. Overview of project topics for running projects (44 topics in total)

Figure 1 and Figure 2 show that there is a priority of topics for emission reduction and alternative fuels which has even increased in more recent projects. Together with 'innovative technologies' these topics are close to half of the past projects and almost 60% of the running projects. On the opposite, loading units and infrastructure have only been looked at in a little more than 10% in past projects, with a decrease to less than 10% in running projects.

The projects can be clustered into the following groups:

- Group 1: alternative fuels (ammonia, natural gas, methanol, ethanol, synthetic diesel, hydrogen, batteries, or combinations thereof);
- Group 2: energy supply improvements;
- Group 3: engine, propulsion, and vessel adaptation;
- Group 4: optimisation of freight management;
- Group 5: Regulations and standards adaptations and improvements;
- Group 6: Communication, training, and awareness.

Although there might sometimes be unclear borders surrounding each of these categories, further analysis will seek to work with these group topics and clustered rather than project- or publication-related results. This analysis will be done at the end of this chapter where the state-of-the-art and the key findings will be summarised and conclusions will be drawn towards the necessary next steps in the analysis.

Table 2 provides an overview of past projects listed in Annex A highlighting their key innovations and whether or not they have (research) elements addressed which are linking to the objectives of this deliverable.

Note: the green label (under the project name) indicates the strength of the link to the objectives, the darker the stronger

Table 3 provides the same type of overview for still running projects.

Table 2. Overview of past projects related to the objective of Deliverable D1.2

Project	Title	Link to objectives
UTI-NORM 1998-1999	Current State of Standardisation and Future Standardisation Needs for Intermodal Loading Units	Project suggested a European loading unit overcoming the shortcomings of ISO containers and swap bodies
TELLIBOX 2008-2011	Intelligent MegaSwapBoxes for Advanced Intermodal Freight Transport	Aimed at all-purpose, intermodal loading unit that is applicable to transport via road, rail, short sea, and inland shipping. The MegaSwapBox was proposed combining the advantages of containers and semi-trailers.
MODULUSHCA 2012-2016	Modular Logistics Units in Shared Co-modal Networks	The project aimed to achieve the first genuine contribution to the development of interconnected logistics at the European level. It developed iso-modular logistics units of sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG)
NEWS 2013-2015	Development of a Next generation European Inland Waterway Ship and logistics system	Developed technical specifications of a novel inland waterway container ship, but was mainly aiming for boosting resource efficiency
#ITS2.0 2014-2020	Inland Waterway Transport Solutions 2.0	Aimed at realising a quick modal shift by introducing new and proven logistic technologies; making better use of existing waterways by developing innovative sustainable small barge concepts; showcasing proven concepts by piloting 8 small waterway modal shifts including solutions for innovative barges¬, waterways, transhipment,¬ (un)loading, freight flow mapping, and modal shift
ST4W 2017-2020	Smart Track for Waterway	Proposed a management solution for shipment by inland waterway transport, incl. automatic update of logistics unit status (pallet, container …), real-time update of ETA (Estimated Time of Arrival) of each logistics unit, throughout the multimodal supply chain; and automatic alert in the case of delay or loading the wrong logistics unit

Note: the green label (under the project name) indicates the strength of the link to the objectives, the darker the stronger

Table 3. Overview of running projects related to the objective of Deliverable D1.2

Project	Title	Link to objectives
IW_NET 2020-2023	Innovation driven Collaborative European Inland Waterways Transport Network	Aims for European Inland Waterways Transport Network by digitalisation, multimodal integration, improved infrastructure management, and green and innovative vessels; increasing modal share
NOVIMOVE 2020-2024	Novel inland waterway transport concepts for moving freight effectively	Identifies gaps in IWT logistics system, innovations such as cargo reconstruction to raise container load factors, and mobile terminals feeding inland barges
PhysICAL	Physical Internet through Co-operative Austrian Logistics	The Pilot 'Smarte Holzlogistik' develops intelligent loading units for wood transport in Austria, aiming for improved transport speed and efficiency, and a modal shift from road to rail.

Note: the green label (under the project name) indicates the strength of the link to the objectives, the darker the stronger

From Table 2 and Table 3 it can be noted that the strongest links were identified with older projects, indicating most of the running projects are no longer focussing on loading units but on CO_2 emissions, alternative fuels, innovative technologies, smarter logistics, IT and IoT, and management systems.

In addition, the analysis of further innovative ideas (see Annex C) has shown that they demonstrate what is or will be possible in the near future. The following categories were identified:

- Loading units and transhipment infrastructure;
- Smart mobility concepts;
- Improved technologies (engine, propellers, CO_2 emissions, etc.);
- Navigation support;
- Urban transport.

The majority of these innovations at the moment lies on emission reduction, urban transport, and climate change adaptation, but seems less on modal shift and loading units. This is principally in line with the analysis of closed and running projects before.

3.2 Publications

Publications in books, journals, conferences and through organisations have been scanned for innovative ideas in vessel design, propulsion, concepts, infrastructure, and greening of IWT but also (to a minor extent) to potential new market developments. The key findings of these publications are listed here with a clear focus on the gaps which were mentioned in these publications.

Many publications were found but evaluated as less relevant for the objective of this deliverable, such as publications on alternative fuels and retrofit of engines. These publications have been summarised in Annex D of this deliverable.

3.2.1 Strategic papers

The 2011 White Paper[17] discussing a 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system' defined specific objectives such as reducing greenhouse gas (GHG) emissions by around 60% by 2050 compared to 1990, limiting the growth of congestion, and reducing oil dependency for a more sustainable transport system. The Green Deal has superseded the ambition later by proposing a 90% GHG emissions reduction for transport[18]. The White Paper put forward a comprehensive list of initiatives to achieve these objectives. It also set ten goals for a competitive and resource efficient transport system which also includes goals for a modal shift as follows:

- 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed;
- A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services;
- By 2020, establish the framework for a European multimodal transport information, management and payment system;

A final evaluation of the White Paper was published in 2020[19] where it was stated that there is still limited progress in addressing road congestions, that some of the 10 previously mentioned goals are believed to be reachable, but others will be not or are too early to assess; and that the needs of EU transport policy, as identified at the time of the adoption of the White Paper in 2011, are largely still relevant today.

Within the framework of the 'European Inland Barging Innovation Platform' (EIBIP, 2017[20]) an EU wide strategy for the uptake of innovation by the Inland Waterway Transport (IWT) sector in the EU has been defined. The report defines six priorities for the EU-Wide Strategy for Innovation Uptake in IWT where the first three deal with greening and low-carbon solutions but the other three also touch upon modal shift:

- **Logistic optimisation of inland waterway transport**: Optimisation of inland waterway transport by means of a further utilisation of existing electronic information and integration of digital and IT tools, contributing to cost reduction (energy-efficient navigation in combination with route planning and optimal cargo load, auto piloting) and service improvement (track and tracing, information systems on route as well as cargo). This should result in the **full integration of IWT in a synchromodal network and a shift of cargo flows to inland waterways**.
- **Active promotion of the modal shift towards IWT:** Provision of logistic advise to cargo-owners and logistic service providers on the use of IWT in their logistic chains, actively promoting the possibilities of it by means of dissemination materials (handbooks, brochures or online) on the (success stories of the) use of IWT, better inclusion of IWT in the logistics education as well as case-to-case advice.

17 European Commission (2011). Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, European Commission. COM(2011) 144 final, 30 pp.

18 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/transport-and-green-deal_en

19 European Commission (2020). Evaluation of the White Paper 'Roadmap to a Single European Transport Area -Towards a competitive and resource efficient transport system'. Staff Working Document: SWD(2020) 411 final, 108 pp.

20 EIBIP (2017). EU-wide Strategy for Innovation Uptake in IWT, version 1. Rotterdam, European Inland Barging Innovation Platform (EIBIP), 54 pp.

- **Stimulation of the development of new markets** for IWT, new types of cargo flows, new sailing areas. This stimulation should be done in direct contact with the authorities of countries, regions with under-utilised waterways, in which best practices of the use of small and urban waterways should be disseminated actively.

These priorities propose digital information, promotion of the modal shift, and new markets, all of which are important but neglect the need for standardised loading units without which a shift from one mode to another will remain very difficult if not impossible.

The DINA document[21], proposing a Digital Inland Wateray Area (DINA) has identified three areas of digitization (navigation and management of traffic, the integration with other modes of transport, especially in multimodal hubs, and a reduction of the administrative burden), identified barriers to its realisation, proposed an architecture for sharing information, and tools for connecting which will be needed. Similar to the White Paper, the report focusses on data exchange and digitisation to foster IWT but the focus is not on modal shift or shift of cargo in between transport modes.

The European Commission Staff Working Document SWD(2017) 223[22] addresses current and future challenges in transport in an integrated manner through seven innovation roadmaps. The document focuses on transport in general, not with the perspective of inland waterway transport. However, these roadmaps reflect 'state of the art' technologies, identify focus areas for research and innovation and actions to enable, and deliver a systemic transformation of the transport system in the short term (2018-2020) and in the medium- to long term (towards 2030 and up to 2050).

In the declaration signed in 2018 in Mannheim[23], the inland navigation ministers of the CCNR Member States (Belgium, France, Germany, Switzerland and The Netherlands) called on the CCNR to press ahead with development of digitalisation, automation and other modern technologies, thereby contributing to the competitiveness, safety and sustainability of inland navigation. They also identified measures to reinforce the role of inland navigation as an economically relevant means of transport with a high potential for development and innovation.

De Vlaamse Waterweg et al.[24] have published an Action and Vision paper in which a common framework for multi-modal data sharing is proposed. In order to guarantee a successful implementation of this framework, a multi-modal data sharing governance ecosystem, a competent coordinating body, sufficient funding[25] and coordinated, and interrelated regulatory actions are said to be necessary. The paper describes three domains (Smart Transport, Smart Logistics, and Smart Admin), three horizons of innovation, and 10 guiding principles. The necessary factors regarding governance, funding, and regulations are also discussed.

The Waterborne Technology Platform (WaterborneTP) has been set up as an industry-oriented Technology Platform to establish a continuous dialogue between all waterborne stakeholders, such as

21 Punter, L.M. and Hofman, W.J. (2017). "Digital Inland Waterway Area - Towards a Digital Inland Waterway Area and Digital Multimodal Nodes". TNO, 94 pp., 3 Appendices.

22 European Commission (2017). Towards clean, competitive and connected mobility: the contribution of Transport, Research, and Innovation to the Mobility package. Commission Staff Working Document: SWD(2017) 223 final, 71 pp.

23 CCNR (2018) Mannheim declaration. https://www.zkr-kongress2018.org/900-en.html

24 VV, INE and EFIP (2020). Towards a climate-neutral, resilient and intelligent synchro-modal automated transport in 2050. A common framework for multi-modal data sharing. Vision and action paper. De Vlaamse Waterweg (VV), Inland Navigation Europe (INE) and European Federation of Inland Ports (EFIP): 11 pp.

25 ‘Funding’ is defined in this document as the act of providing resources, mostly of financial nature and from public sources, to a programme or project. Sources of funding include credits, venture capital, donations, grants, and subsidies, see also https://en.wikipedia.org/wiki/Funding.

classification societies, shipbuilders, shipowners, maritime equipment manufacturers, infrastructure and service providers, universities or research institutes, and with the EU Institutions, including Member States. The platform currently coordinates the he Co-Programmed Partnership on Zero-Emission Waterborne Transport (ZEWT cPP) in the framework of Horizon Europe (HEU). The Partnership's activities will provide and demonstrate zero-emission solutions (propulsion, energy efficiency, vessel design & retrofitting, etc.) for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050 for the waterborne transport sector. These will be based on its Strategic Research and Innovation Agenda (SRIA, June 2021)[26]. The ZEWT SRIA will constantly be updated to ensure that the efforts of the waterborne transport community are channelled in the best directions for the sector to reach is decarbonization targets. PLATINA3 is also one of the projects that will support an update of the SRIA Roadmap, during 2023.

In addition, WaterborneTP has also published three other relevant SRIAs, which cover topics outside of the ZEWT cPP remit, as well as a SRIA 'Annex' covering transversal aspects:

- The Strategic Research and Innovation Agenda Ships & Shipping (2021)[27]. It focuses on aspects such as ICT systems (digital twin, automation, robotization, etc.), safety and regulatory issues. It is one of the SRIAs relevant for the purpose of this deliverable;
- The Strategic Research and Innovation Agenda Ports & Logistics (2021)[28]. This documents focuses on the seamless integration of port operations and logistics with their need to decarbonize. This SRIA is highly relevant for the work undertaken within this deliverable;
- The Strategic Research and Innovation Agenda Blue Growth (2021)[29]
- The Strategic Research and Innovation Agenda Transversal Aspects (2021)[30].

The ALICE Roadmap on "Corridors, Hubs, and Synchromodality"[31] aims at the achievement of EU wide co-modal transport services within a well synchronized, smart and seamless network, supported by corridors and hubs, providing optimal support to supply chains. It involves a step change from the current system, towards the ultimate vision of the Physical Internet, by synchronizing intermodal services between modes and with shippers (referred to as Synchromodality), aligning equipment and services on corridors and hubs and integrating these into networks. ALICE defines synchromodality, or synchronized intermodality, as the service which, through informed and flexible planning, booking and management, allows to make mode and routing decisions at the individual shipment level, as late as possible in the transport planning process including the trip itself. It assumes that with the Physical Internet in mind, (hardware) technologies moving towards strong modularity, connectivity and self-organization will appear.

The paper concludes that in order to reach synchro-modality, a Common Framework for multi-modal digitalisation is necessary. For a smooth implementation of such a Common Framework, a multi-modal data sharing, a competent coordinating body, sufficient funding and coordinated, and interrelated regulatory actions are necessary. The link to EU policy initiatives such as the creation of the dataspaces, high-value datasets, the revision of the TEN-T regulations, the ITS and RIS directives, as well as the next steps of the eFTI regulation are still to be explored.

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[26] Strategic Research And Innovation Agenda for The Partnership on Zero-Emission Waterborne Transport

[27] 210606_SRIA_non-cPP_Ships__Shipping_Final.pdf (waterborne.eu)

[28] 210609_SRIA_non-cPP_-_4_-_Ports_Logistics.pdf (waterborne.eu)

[29] 210603_SRIA_non-cPP_-_3_Blue_Growth_final.pdf (waterborne.eu)

[30] 210615_SRIA_non-cPP_-_5_-_Transversal_Aspects_final.pdf (waterborne.eu)

[31] ETP-ALICE (2021). "Corridors, Hubs and Synchromodality - Research & Innovation Roadmap", ALICE - Alliance for Logistics Innovation through Collaboration in Europe, 44 pp.

The European Commission has published a 'Sustainable and Smart Mobility Strategy' in 2021 under titled as 'Putting European transport on track for the future'[32]. The publication details the EU vision for the future in mobility with clear steps for 2030, 2035, and 2050, focussing on zero-emission vehicles, and increasing rail freight traffic. Ten so-called flagships have been identified, two of which are also dealing with modal shift and smarter mobility.

Recently, the European Parliament has published a resolution towards future-proof inland waterway transport in Europe[33]. The resolution calls on the Commission to foster 1) a modal shift from road to IWT (12 action points), 2) greening of IWT (10 action points), 3) digitalisation and autonomous shipping (9 action points), 4) future-proof ports as energy and circular hubs (7 action points), 5) education and training, working conditions, and research and innovation (4 action points), 6) EU funding(11 action points through existing EU funding instruments, a new EU inland waterway fund, and the EIB), and 7) passenger transport, urban mobility, waterborne city logistics and tourism (5 action points).

3.2.2 New markets

The EU has defined an industrial strategy around 14 industrial ecosystems[34] (Figure 3) one of which is the mobility – transport – automotive ecosystem.

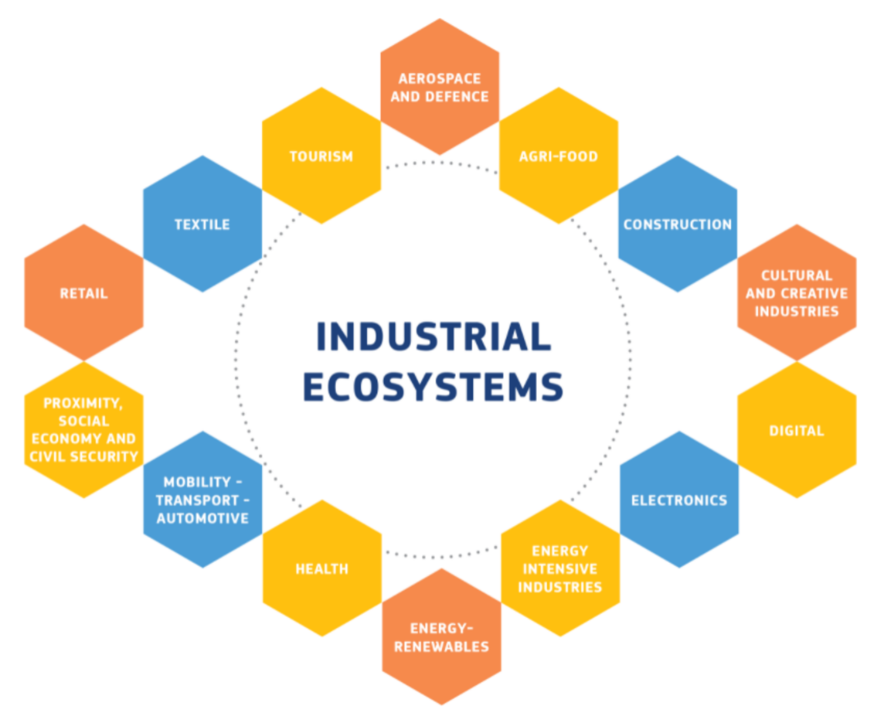

Figure 3. Industrial ecosystems (source: EU[34])

32 European Commission (2020). Sustainable & Smart Mobility Strategy: Putting European transport on track for the future, European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 21 pp., 1 Annex.

33 European Parliament (2021). European Parliament resolution of 14 September 2021 towards future-proof inland waterway transport in Europe. Strasbourg, European Parliament. P9_TA(2021)0367: 2021/2015(INI), 16 pp.

34 https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

The Annual Single Market Report 2021[35] provides an analysis of the economic and social impact of COVID-19 on the European Single Market. It also elaborates on the 2020 Single Market Enforcement Action Plan, and Industrial and SME strategies, and provides details of all 14 industrial ecosystems.

Waterborne transport is the smallest of the 8 sectors within the Mobility - Transport - Automotive ecosystem. Key challenges in this ecosystem are decarbonisation, digitalisation, and global competition, all of which require large investments in new technologies, infrastructure, and re-skilling of the workforce.

With respect to waterborne transport, the report suggests investments to support the transition to automation and digitalisation (waterway infrastructure and traffic management systems) which is seen as means to foster modernised vessels and better connectivity to other modes. 5G is seen as an enabler for more digitalisation in the ecosystem.

Other ecosystems such as the construction ecosystem (decarbonised buildings) or the renewables ecosystem (battery production, significant market growth, critical raw materials supply) will have to rely among others on transport flows to achieve the defined goals.

The PLATINA3 Stage 3 event on 10/11 February 2022 included presentations and discussions on new markets which might be able to trigger a modal shift towards inland waterway transport. The following options were mentioned or discussed:

- waste / biomass transport;
- circular economy / new materials;
- urban logistics;
- new (alternative) energy;
- hydrogen & other alternative fuels;
- climate related markets (CO_2 transport);
- new trade routes, connection to TEN-T;
- passenger transport.

It became clear however that the impacts of most of these new markets on inland waterway transport are very uncertain or may not even have an impact. The shift to a different transport mode is very often not triggered by the market area being new but also (and even more importantly) on other factors such as the business case, legislations, incentives, etc.

Further investigation is needed to determine which of these new markets require which sort of adaptation of IWT. Can the respective products / materials be transported with existing vessel types and existing infrastructure or are adaptations needed?

The open question before investing in any of these new markets is therefore how future-proof and long lasting these markets are. Investments in fuel additives (and the corresponding infrastructure) are more than questionable if in ten years' time a regulation prevents the fuel from being further used. Adaptation of the fleet to new requirements will not be meaningful if these adaptations are no longer needed. The more future-proof the market is, the more certain is the potential shift to IWT. On the other hand, there is always competition with other modes of transport which will also decarbonise (and possibly faster than IWT) and therefore might still offer a better solution.

Potential obstacles to these new markets were discussed as follows:

- Regulations (e.g. biomass)

[35] European Commission (2021). Annual Single Market Report 2021, European Commission. Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: SWD(2021) 351 final, 40 pp., 4 Annexes.

- Technological maturity (very often not at TRL 7 or higher)
- Flexibility (better lack of flexibility)
- Competition
- Costs
- Port congestions (seaports)
- Fairway conditions / maintenance
- Infrastructure conditions
- Change to e-trucks will be faster than change to e-vessels, therefore road will be competitive sooner or later, i.e. one advantage of IWT will get lost

The most recent market study by CCNR, in collaboration with the EC (2022)[36] has focused on an assessment of upcoming new markets for inland waterway transport and its implications for the sector. The study is based on statistical data, literature research, and expert interviews and has identified four key new markets:

- Urban passenger transport by inland vessels in the form of public local transport (examples are found in Antwerp, Brussels and Rotterdam).
- Urban freight transport by inland vessels (construction material, food products, parcels, etc.) in large cities such as Amsterdam, London, Paris, Lyon.
- New cargo flows stimulated by circular economy strategies (e.g. waste transport).
- Transport of renewable energies or components for their generation (biomass, biofuel, hydrogen, wind turbines).

Whilst the passenger transport is not the focus of this report, the other three markets are in line with previous observations from other sources. The study stresses that these markets all exist, have differently large potential but also vary in the difficulty to access these markets due to intermodal competition, commercial, logistical and technological challenges, risks and uncertainties.

3.2.3 Ship designs

De Leijer et al. (2015) in their Good Practice Manual proposed, amongst other suggestions, three new ship designs for the Danube river (two pusher types, one self-propelled) leading to cost and energy savings under the pre-requisite of a good fairway maintenance. In addition, a new vessel design for the Paraná River in Paraguay has been discussed showing that many vessel designs need to consider the local conditions like draught, fairway conditions, operational stretches, types of freight, etc.

Sihn et al. (2015)[37] introduced the ideas, concepts and first results of the NEWS project (see Annex A). They introduced the innovative NEWS container vessel for the Danubian waterway system, featuring an adjustable LNG electric propulsion system and claimed significant reductions of ecological impacts and considerable reductions of climate change costs.

EIBIP et al. (2017)[20] have investigated the needs for new vessel concepts and argued that those are specifically needed for a better use and/or optimisation of cargo flows on small inland waterways. Examples are Q-Barge, Barge Truck, and Watertruck, all of which use small push boats in combination with self-powered barges. Furthermore, the use of autonomous vessels has been investigated and links are made to the Roboat system, see the specific section in Annex C.

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[36] CCNR (Central Commission for the Navigation of the Rhine) (2022). An assessment of new market opportunities for inland waterway transport. Strasbourg, CCNR, EU, 151 pp., 2 Annexes.

[37] Sihn, W., Pascher, H., Ott, K., Stein, S., Schumacher, A. and Mascolo, G. (2015). A green and economic future of inland waterway shipping. The 22nd CIRP conference on Life Cycle Engineering: pp. 317-322.

Bernardini et al. (2018) proposed a new ship design for less fuel consumption[38]. The authors claimed that the design choices related to the adoption of an Air Cavity System and of a modern vertical propulsor, have influenced the optimisation process of the hull form, determining a shape suitable to sail in different environments (shallow and deep water) at different speeds and hydrodynamic regimes, without losing to much efficiency as highlighted also by model tests. The integration of three elements:

- an optimized hull shape,
- an innovative propulsor, and
- a gas-fuelled propulsion plant

has led to a pollution reduction, lowered fuel consumption, and a reduction of the operational costs. Overall, the research shows that the combination of various factors should be considered and can lead to higher efficiency and hence less fuel consumption, and fewer emissions.

Radojčić et al. (2021) have recently discussed the design of contemporary inland waterway vessels for the Danube river[39]. The book discusses the influencing factors for the design (5 chapters), the design guidelines based on shallow water hydrodynamics (2 chapters) , and innovative technologies and design solutions (3 chapters) for contemporary vessels for the Danube river. Further details regarding the fleet are provided in WP 2 of PLATINA3, and more specifically in Deliverable D2.2 where options for shallow water and climate resilient vessels are discussed.

3.2.4 Loading units and transhipment infrastructure

In SKV (2003)[40], an overview is provided over presently used loading units such as containers, swap bodies, and semi-trailers. The report provided definitions, dimensions, weights, transhipment solutions for these types of loading units and discussed the issues of these units in inland waterway transport such as:

- width of loading unit:
  - lock width allowing for a maximum external vessel width of 11.4 m;
  - pallet stowing pattern which typically optimises only for a mixed stowing pattern using different pallet types;
- height of loading unit:
  - typically, the European canal network accommodates barges with two layers of boxes on board, the river Elbe and parts of the French network can accommodate up to three layers, and the Rhine and the lower part of the Danube and some major canals in the Netherlands up to four layers;
  - one single bridge can limit the access to that specific waterway;
  - ballast techniques can help in overcoming height issues, but cause additional costs
- length:
  - similar to the width issue, the length of locks determines the optimal use / stowing pattern of loading units

38 Bernardini, A., Cok, L., Baroni, C., Legittimo, C.M., Marino, A., Mauro, F., Nasso, C., & Bucci, V. (2018). An Innovative Concept for Inland Waterway Vessels. In A. MARINÒ & V. BUCCI (Eds.), Technology and Science for the Ships of the Future (pp. 35-42): IOS Press.

39 Radojčić, D., Simić, A., Momčilović, N., Motok, M. and Friedhoff, B. (2021). "Design of Contemporary Inland Waterway Vessels. The Case of the Danube River". Cham, Switzerland, Springer, 337 pp. https://doi.org/10.1007/978-3-030-77325-0.

40 Studiengemeinschaft für den Kombinierten Verkehr (SKV) (2003). Intermodal loading units, European Strategies to Promote Inland Navigation (SPIN – TN). WG3 Intermodality & Interoperability, 51 pp.

- stacking problem:
  - not all loading units are stackable which implies restrictions to the optimal use of inland waterway vessels;
  - (regional / national) stability requirements apply which have to be met and which are often not standardised[41];
- Transhipment:
  - Optimal space solution only via Load-On Load Off (LoLo), not Roll-On Roll-Off (RoRo), therefore many loading units not allowing for LoLo are not suitable for wider use in IWT
  - equipment of loading units with top corner fittings for top lift by spreader is necessary to be of universal use

Eventually, the report also discussed the standardisation efforts to get to a European loading unit.

The paper by Jeschke (2011)[42] has discussed upcoming global trade routes and their implications on loading units. The key findings were:

- a slight shift to more locally produced and more "ethical" goods (e.g. fair trade or controlled organic products) is foreseen;
- the BRICS states Brazil, Russia, India, China and South-Africa in particular will become increasingly dominant whereas Europe's relative importance will shrink in global transportation in the future;
- in general, socio-economic trends such as the oil price and supply, environmental awareness of society and changes in consumer behaviour, re-regionalisation, legislative frameworks, and infrastructure constraints define the requirements for future international loading units;
- it remains, however, impossible to find a one-fits-all international loading unit which covers all requirements;
- the market introduction of the 45 ft palletwide container provides a feasible approach to overcoming these challenges, see also below; Tellibox and micro-containers may serve as future loading units;
- the transport means distributing the loading units from the overseas harbours to their final destinations are dependent on the constructive framework of the container vessels;
- a transport industry-wide consensus on the right dimensions of loading units together with the support of policy makers to ensure the efficiency of future transport flow. This approach combines the requirements and needs of all transport modes and is the only way to facilitate intermodal transport.

POM Oost-Vlanderen (2019)[43], within an INTERREG #IWTS 2.0 study, has provided an overview of transhipment infrastructures available on the market (market study from 2018-2019). The infrastructure focussed on bulk, palletized goods, project cargo, and containers. For each infrastructure asset, one or several photos, the financial and operational characteristics, the minimum required waterside infrastructure, and some remarks are provided.

There are 17 assets listed for bulk, 4 for palletized goods, 15 for project goods, and 5 for containers. Although this might not be representative for the whole sector, it shows already that the diversity for

[41] This issue was solved with amendment of Rhine police regulations by the CCNR (Resolution 2014-II-14, Article 1.07(4)). The latter is used as blueprint for the national police regulations in Europe.

[42] Jeschke, S. (2011). Global Trends in Transport Routes and Goods Transport: Influence on Future International Loading Units. Discussion paper – 16th ACEA SAG Meeting, RWTH Aachen University, Institute of Information Management in Mechanical Engineering (IMA): 32 pp.

[43] POM Oost-Vlaanderen (2019). Overview transshipment methods, European Union, INTERREG North-Sea Region, #IWTS 2.0, 47 pp.

bulk and project goods, provided in different shapes, sizes, weights, etc. are significantly larger than for more standardised products than pallets and containers.

Paddeu et al. (2019) have looked into new technologies and automation in freight transport and transhipment infrastructure[44]. Even though there is a focus on road and rail transport, also maritime transport is mentioned, specifically addressing the automation in stacking equipment in transhipment hubs. Policy recommendations were compiled, the most relevant for (or translated to) inland waterway transport are:

- Continued investment in Europewide high-speed, high-capacity data transmission networks (both fibre-optic and mobile)
- Developing a strategic plan to support the private sector to adopt and develop new systems of freight handling and movement, including
  - providing financial support for research and development programmes, with trials objectively and fully evaluated (to generate compelling evidence of efficacy relevant for knowledge transfer the sector); and
  - training programmes to increase workforce capacity regarding the adoption of new operating practices

3.2.5 Summary

There are several publications in the area of inland waterway transport, and dealing with various research topics such as the (future) strategy of inland waterway transport, new markets, ship designs, and loading units. These clusters of publications are (somewhat) overlapping with what has been identified as project groups. Research efforts therefore go in different directions to achieve the EU targets for transport and mobility but also to accommodate 'external drivers' such as climate change or new markets. There is, however, a clear trend going towards the utilisation of improved technology (digitalisation, fuels, engine and vessel adaptation, automated systems, etc.).

Many of the aforementioned solutions for new types of fuels, retrofits, technical solutions, and ship designs will need to build on changes or amendments in the existing infrastructure of inland waterways. Smart terminals and/or smart systems (e.g. hub and spoke system in container transport) are already discussed and of course closely interrelated to any new types of vessel designs.

3.3 Other initiatives

This section summarises initiatives and actions which were not directly fitting under the previous sections of this chapter but are relevant for an inventory of the current state-of-the-art in transport and logistics.

3.3.1 ILU-Code register

The European standard EN 13044-1 introduces an owner-code for the identification of European intermodal loading units (e.g. swap-bodies, semi-trailers), the so-called ILU-Code[45], which is compatible with the worldwide BIC-Code used for containers according to ISO 6346. UIRR (International Union of combined Road-Rail transport companies), located in Brussels, is the administrator of the code.

44 Paddeu, D., Calvert, T., Clark, B. and Parkhurst, G. (2019). New Technology and Automation in Freight Transport and Handling Systems. Future of Mobility. Foresight, University of the West of England, Bristol, 71 pp.

45 https://www.ilu-code.eu/en/

The associated ILU-Code register lists all owner keys (four letter code) from 2011 onwards and is publicly available and downloadable. The ILU-Code will

- simplify the electronic data processing and operations of the transport chain;
- allow to use all swap bodies and semi-trailers to be used in rail transport once they are equipped with the owner key / registration key / check digit system;
- allow all the actors of the transport chain, as well as third parties, for example customs authorities, emergency services, etc. at any time to identify the owner of a loading unit;
- be OCR readable and therefore allow the same systems as already installed at ports to be installed at continental terminals and increasing their efficiencies.

3.3.2 e-FTI

The electronic freight transport information (e-FTI) contains regulation 2020/1056[46] establishing a legal framework for the electronic communication of regulatory information between the economic operators concerned and competent authorities in relation to the transport of goods on the territory of the EU. Full application of the regulation by all member states is currently planned for August 2025.

The DTLF (Digital Transport and Logistics Forum) is an expert group of the European Commission bringing together public and private stakeholders from various transport and logistics communities. The DTLF, together with its subgroups and teams, provides technical assistance for the implementation of e-FTI.

3.4 Summary and conclusions

This chapter has provided an inventory of various sources with relevant information for the topic of this deliverable. Projects, publications, innovative idea publications, and websites have been scanned to not only find the state-of-the-art knowledge on the topic but also to identify the key necessary conditions needed for a market uptake.

Future developments remain difficult to predict since they are very often performed as an extrapolation of the past which assumes that an existing technology continues to exist but at a larger quantity or speed, and ignoring new technologies which often trigger paradigm shifts and completely new ways of thinking. Despite these flaws in forecasting or prediction of the future, the following trends are visible:

- **Digital transformation, ICT-based technology, and big data:** the increased use of internet and modern ICT-based technology (IoT) will play an increasingly significant role in mobility and transport. This new era has already started and will grow, possibly exponentially, in the coming years. Data security and ownership, legislations, and disruption of internet-based services will be critical to solve alongside this development. This trend will play a fundamental role also with respect to modal shift or intermodal transport, easing the access to critical transport-related information and exchange of data. **Automation,** as a part of digital transformation, will alter transport significantly with respect to vehicles and hubs, highways, and urban transport. With respect to vessel design, operational aspects and future digital capabilities such as 5G-based devices and teleoperation will pave the way to vessel automation. To increase the market share, more specialized programs will have to be devised to accommodate the lack of skippers and adjust vessel design capabilities to allow for diverse types of operations (equipment, sensors/telematic devices, and ICT knowledge). Example are the Seafar-project (see Annex C)

46 https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32020R1056

and its services (https://seafar.eu/), or SSAVE, see Annex A. Although with a huge potential, automation may remain perceptive to any form of disruption like unforeseen obstacles, failure of controls, communication failures, etc. Whether or not this trend will contribute to different vessel types and/or loading units will remain to be seen. However, for improving ICT technologies in the IWT ecosystem, there will be an obvious need for interoperability and harmonization of all systems to achieve efficient, effective and sustainable operations;

- **Alternative fuels**: new types of fuels will assist in de-carbonisation and might also be an opportunity as cargo for IWT. Given the shortage of fossil fuels, alternative fuels will have to be available rather sooner than later. Any infrastructural changes which will eventually be necessary for modal shift or inter-/multi-modal transport, will therefore need to consider additional requests from this side;
- **Electrification:** Electrically-driven vehicles are still at the forefront of alternatives to fossil fuels fuels, in IWT especially for shorter distances. It remains, however, dependent on infrastructural support and strategies;
- **Alternative modes:** several developments have been introduced (e.g. Maglev = magnetic levitation or guided tube concepts = "hyperloops") which could improve the speed of transportation, although many of them do not have a positive business case (yet). For the time being and for this deliverable, these trends are therefore not further considered here;
- **New materials:** they are not necessarily a major leap in transport technologies but might assist in reducing construction and maintenance costs, durability, reliability, and speed of constructions, all of which assist in more efficient transportation. They might also play a role in developing new loading units or even infrastructure (elements) and any developments here might therefore be worth monitoring;
- **Change of drivers:** whilst most technical innovation in transportation (and other sectors) come from private industry, the public sector plays a significant role in supporting the innovation and driving the sector (by means of infrastructure, regulations, funding, energy supply, environmental issues, etc.). In addition, innovation can also be triggered by regulations and incentives, examples are European research projects which follow EU visions and hence funding schemes.

Key topics identified from the inventory within this chapter have been summarised in a mind map shown in Figure 4.

Figure 4 shows that there are six relevant clusters (EU, New markets, External drivers, Enabler, Barriers, and Innovation) all of which bring together specific topics which either have an influence on IWT or a bilateral relation. Some topics are overlapping in between clusters (e.g. energy transition in between clusters 'New markets' and 'External drivers' or mind shift in between ‘Barriers’ and ‘Enablers’). Other topics, such as legislation/standardisation might also be listed under clusters such as 'Enablers', depending on what the status of legislation/standardisation for the specific topic is.

On the positive side, the key findings of the performed survey can be summarised as follows:

- There are new markets arising with sufficient potential to be used for inland waterway transport;
- There are technical solutions possible to provide the infrastructure for such solutions;
- Digitalisation technology is improving and getting more and more available and market-ready. Together with 5G, digitalisation will help in improving the speed, efficiency, safety, and reliability of mobility and transport. It will also help increase automation of vehicles and terminals or hubs;
- There are strategic ideas available to adapt the transport on inland waterways to match the requested demands of the future;

- Shippers are becoming more aware today that they have to change their behaviour in order to reach a more sustainable transport system. A mind shift could therefore also be seen as a key enabler for shifting to IWT from that perspective.

On the other hand, the survey also shows:

- A modal shift is not happening (fast enough) since common loading units are not available for all relevant modes. The competition between transport modes is still too large to shift cargo easily from one transport mode to another;
- Intermodal transport suffers from the same issue, namely the standardisation of loading units to be used. In addition, infrastructure is not always available and requires substantial investments. Although digitalisation will assist in improving the speed of transhipments at hubs, costs and speed at transhipment hubs might still need more innovation;
- The sector is geographically too large and seems financially not strong enough to move fast in a certain direction. Providing the right fleet, with the agreed loading units, and with the right infrastructure along all major inland waterways remains impossible if there is no common agreement amongst all stakeholders.

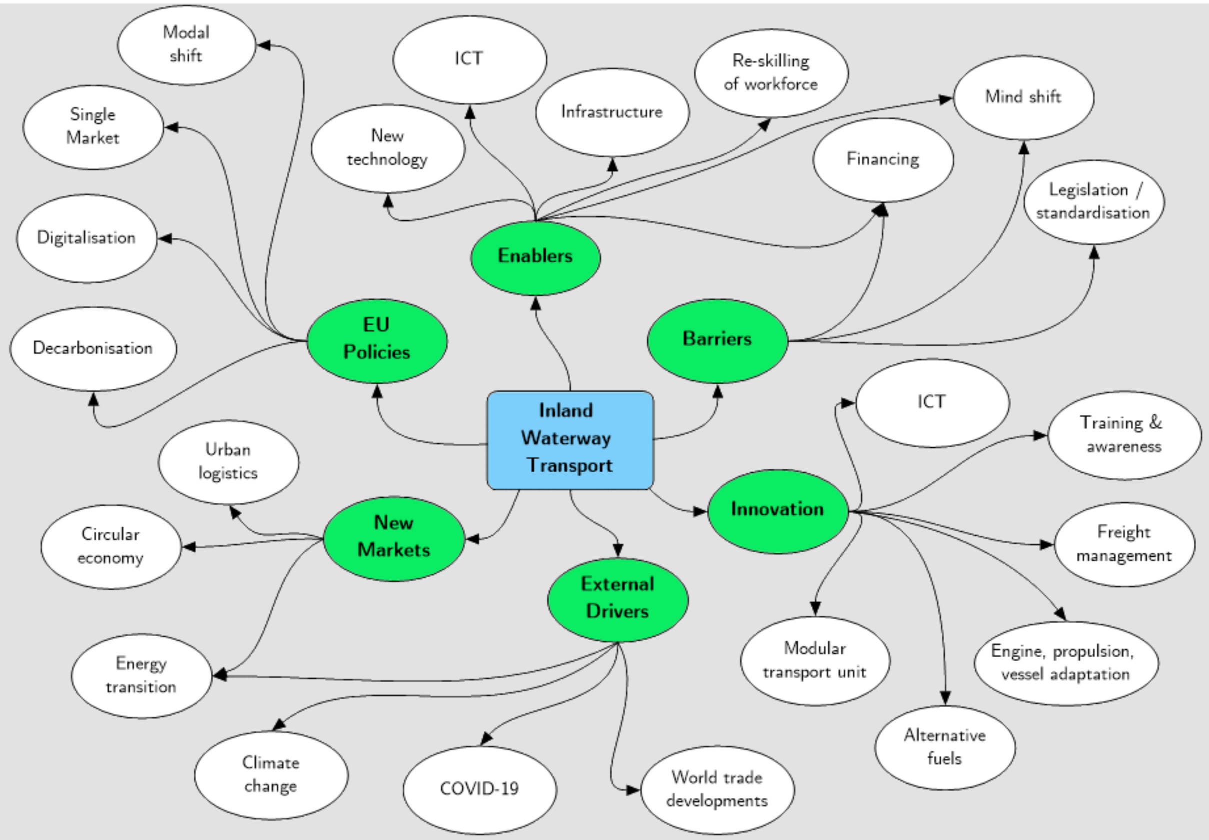

Figure 4. Relevant clusters and topics identified around inland waterway transport

In conclusion from these findings, the following chapters will first deal with a more detailed analysis of gaps related to the various topics of the inventory (chapter 4), and, secondly, discuss possible measures to reach the required market uptake (chapter 5).

4 Gap analysis

This chapter seeks to identify and further analyse the existing gaps in development for inland waterway transport. To achieve this, section 4.1 first looks into a matrix comparison of identified related topics around inland waterway transport (see Figure 4), all of which are then further detailed and analysed in sections 4.2 to 4.5. Section 4.6 summarises the findings of this chapter.

4.1 Gap identification

The topics around inland waterway transport which have been clustered from the inventory of chapter 3 (see Figure 4) have been added to the rows and columns of a matrix as indicated in Figure 5 (a larger version of the figure can be found in Annex F). Note that the topics use 3-letter-indicators which are explained in the legend of Figure 5. The matrix then contains cells below and above the diagonal, which contain:

- The existing 'correlation' in between the two topics indicated by the row and column of the cell below the diagonal
- The expected changes of the 'correlation' to reach to the desired correlation in between these topics above the diagonal

A colour code system has been used assigning various shades of orange to each of the cells, depending how strong the 'correlation' seems to be from the inventory of chapter 3. Darker orange means stronger correlation and lighter orange indicates less correlation.

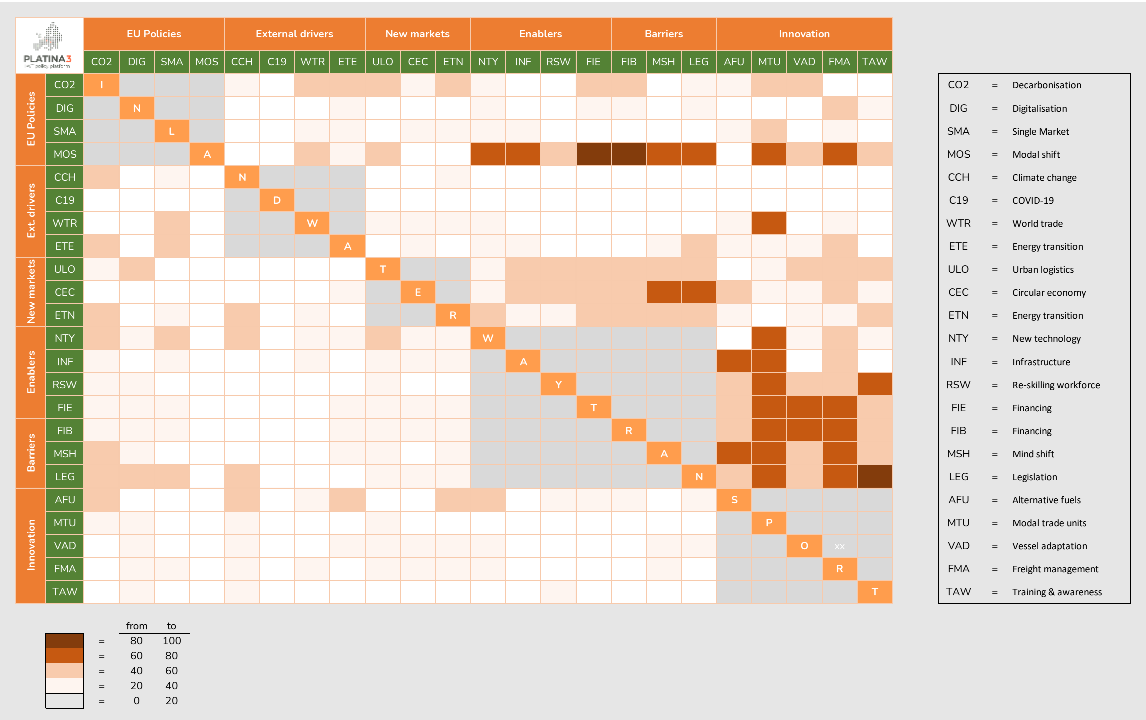

Figure 5. Gap identification matrix for topics around IWT (for topics see Figure 4, a larger version of this figure is displayed in Annex F)

Using the colour coding system of Figure 5, darker cells indicate that there are more efforts needed to reach the desired correlation in between two topics.

Example: the column MTU (= modal transport unit, fourth but last column in Figure 5) shows a first darker cell against the row (MOS = Modal shift). The 'correlation' in between these rows is desired to be rather large (no modal shift without the loading units) but is (right now) rather low. It should, however, be noted that the associated number of 'correlations' was subjectively filled (based on the inventory performed) and is therefore prone to variations.

The matrix therefore provides a simple way to find out where larger efforts are needed and in which topic. The following pairs of topics can therefore be identified (using cells with numbers from 60-100, see legend in Figure 5, and focusing on modal shift, loading units, and infrastructure only):

- 'Modal shift'
  - Enablers: 'New technology', 'Infrastructure'
  - Barriers: 'Financing[47]', 'Mind shift'
  - Innovation: 'Modal trade units'
- 'Modal trade units'
  - Enablers: 'New technology', 'Infrastructure', 'Re-skilling of workforce'
  - Barriers: 'Financing', 'Mind shift', 'Legislation'
- 'Vessel adaptation'
  - Barriers: 'Financing'
- 'Freight management'
  - Barriers: 'Financing', 'Mind shift', 'Legislation'

Note: the aforementioned topics, especially in relation to ‘barriers’ might need further explanation. For example, financing can be both an enabler and a barrier. Without financing, a specific innovation would probably never be realised whereas too little financing would be a barrier to its realisation. The same holds true for legislation and its role in realising new ideas or innovations. Both financing and legislation are therefore ‘forward looking’ and meant in terms of future steps to realise the respective innovation. They are not meant looking backwards as a kind of realisation what has been achieved so far.

4.2 Standardised loading units

The container is still seen as a driver for any intermodal transportation[48]. Two key characteristics might have supported the development of containers, which is first that the container has not been patented (on purpose); and second that it got standardised within the first ten years after invention (ISO 668). The TEU (Twenty-foot Equivalent Unit), mostly made of steel, is 20 feet long, 8’6” feet high, and 8 feet wide (6.1 m long, 2.6 m high, 2.45 m wide). There are mainly five types of containers such as:

- Standard container;
- Tank container;
- Open top container;
- Flat container;
- Refrigerated container (reefer).

47 Financing, other than funding (see footnote 25), refers to the act of providing external capital to a programme or project where this capital is often private capital

48 Rodrigue, J.-P. (2020). The Geography of Transport Systems, Routledge, Taylor & Francis Group, Fifth Edition, 456 pp.

Large varieties of containers also exist depending on its geographic origin and specific use. Various projects in the EU (see section 3.1 and 3.2.4) aimed at improving the dimensions of the standard sized containers (20 ft and 40 ft) to accommodate EU regulations, inland waterway restrictions (e.g. dimensions of locks, etc.), EU pallet sizes, and more. Only UNIT45.COM, see footnote 158, seemed to have established a company in the market around developing a 45 ft container (as a standard), but being flexible towards requests of customers.

Swap bodies and semi-trailers have clear disadvantages in handling during transhipment, either by using more space in between units, safety issues, extra equipment needs, etc. However, all loading units need specific equipment during any transhipment operation which means the necessary spreaders, cranes, or other devices need to be available at transhipment points.

Reasons for the lack of standardisation in loading units could be similar to what has been observed in the past:

- Competition between modes
- Complexity of standardisation (mainly in meeting all constraints and requirements from all modes)
- Silo thinking without triggers or incentives to involve different modes of transports
- loss of advantages in cost, service, reliability, and safety
- difficulties in transhipment or missing transhipment infrastructure
- insufficient share or size of cargo being transported in loading units

Hence, there is still a gap of finding the right loading unit, although a modification of the container (or several modifications) seems promising. Rather than modifying the loading units, a change in handling the existing (diverse) loading units might be more promising. Examples are the CargoBeamer initiative, see footnote 159, or the Danubia-Kombi concept, see footnote 160. Whilst the former is meant to trigger a modal shift in between road and rail and would therefore need a 'translation' for road to IWT, the latter is a possible solution for different types of goods, allowing for stackable 'units' on barges, but would need adaptations in vessels and crane facilities. Also the idea has been developed for the Danube (region) and wider applications to other regional domains in Europe need to be discussed.

Different sizes of loading units have been explored for different applications, see e.g. MODULUSHCA (Annex A), CLUSTERS 2.0[49] (2017 – 2020), or 'Less than Wagon load'[50] (2017 – 2020, focusing on the chemical industry in the Port of Antwerp). Further projects were or are working on loading units, e.g. AEGIS (Annex A), the recently started MULTIRELOAD project[51] (2022-2025), but also some private companies (e.g. AELER[52], 4FOLD[53]) developing new concepts and market solutions.

ALICE, as part of their BOOSTLOG project[54] (2021 - 2023), will carry out a cloud report on Physical Internet including modular units and transhipment (planed in 2023), focussing on modularization and transhipment, by scanning running and previous research projects such as mentioned before.

Given that dry cargo still plays a significant role (60% in EU27 in 2020) in inland shipping, see footnote 36, it can be assumed that there will be continuous parallel (dry) cargo transport within the near future.

49 http://www.clusters20.eu/
50 http://lessthanwagonload.eu/
51 https://www.etp-logistics.eu/multireload-a-transnational-innovation-project-bringing-european-inland-ports-into-the-spotlight/
52 https://www.aeler.com/
53 https://4foldcontainers.com/
54 https://www.etp-logistics.eu/boostlog/

4.3 Transhipment infrastructure

Transhipment infrastructure has historically developed alongside inland waterways, depending on the geographical environment, length and connections of the waterway, the cargo transported, the vessel type, and various other factors. The present state has been summarised in POM Oostvlaanderen, see footnote 43, whereas some developments were shown in Paddeu et al. (2019), see footnote 44. From the overall trends and policies in transport and mobility, it can be concluded that digitalisation and ICT-based technology will be influencing transhipment infrastructure as well, e.g. by automation or remote control of operations.

The key barrier for any investment in this or similar directions will be:

- The lack of a clear roadmap to where inland waterway transport is moving to;
- The high risk of investing large CAPEX for infrastructure which might be no longer needed (much) before the lifetime of the asset;
- The uncertainty of regulations which will influence the revenues of any investments;
- The future of inland waterway transport in general where incentives and regulations can either stipulate increasing or decreasing traffic (and hence use of infrastructural assets);
- Spatial constraints for installing new infrastructure (additional space in ports and hubs is sometimes very limited).

It seems that the sector here is very much dependent on developments of IWT, the vessels, their fuels or energy sources, the maintenance policies, and various other factors. Predictability of what will come at which point in time remains extremely difficult and is therefore a very risky investment for any investor.

4.4 New markets

The EU industrial strategy has identified 14 so-called industrial eco-systems (see Figure 3). The EU Single Market report suggests investments to support the transition to automation and digitalisation (waterway infrastructure and traffic management systems) which is seen as means to foster modernised vessels and better connectivity to other modes. 5G is seen as an enabler for more digitalisation in this ecosystem.

Evolving markets for inland waterway transport were also identified during the PLATINA3 Stage 3 event and have (partly) also been listed and underpinned by the recent CCNR Market study, in collaboration with EC, see footnote 36, as follows:

- waste / biomass transport;
- circular economy / new materials;
- urban logistics;
- new (alternative) energy;
- hydrogen & other alternative fuels;
- climate related markets (CO_2 transport);
- new trade routes, connection to TEN-T.

Various barriers have been discussed and listed during the Stage 3 event (and amongst literature):

- Regulations (on different levels and topics);
- Matureness of technology (very often not at TRL 7 or higher);
- Flexibility (better lack of flexibility);

- Competition;
- Costs;
- Fairway conditions / maintenance;
- Infrastructure conditions.

New markets will evolve independently from any activities or triggers in inland waterway (transport) since the sector is too small for influencing market developments and world trade activities. The relevant question is therefore whether the sector is prepared for any new market development (or, alternatively, has the ability to adapt to it quickly). Adaptability, flexibility, and resilience is therefore crucial for any market uptake, also in connection with other transport modes. Since very often, transport systems have a rather large inertia and cannot easily adapt to entirely new demands (requiring e.g. different vessels and infrastructure), it is therefore also crucial to be very flexible in all elements (vessel, infrastructure) of the system so that the system can adapt to changes as much as reasonably possible.

4.5 Other

Chapter 3 also discussed an inventory of smart mobility ideas and projects. These comprise new ideas and developments linked to improved ICT technologies, such as:

- real-time collection of ship and river data (River Information System);
- digitalisation of waterways across Europe;
- remote control and/or automation of vessel operations;
- improved (digital) registration of vessel, travel route, and good details;
- improved handling of small barges and 'platooning' (as for future trucks on motorways);
- improved traffic management systems;
- improved load factors of inland waterway vessels by optimised planning tools;
- improved ETA prediction through better (and digital) data exchange;
- awareness raising for the role of the sector and its efforts to mitigate climate changes.

The key source for achieving these improvements is data and its exchange to the various stakeholders involved. The data are not only describing the vessels but also the transported cargo, route information, customs information, waterway information, incl. assets such as locks and ports. The more data are known (and efficiently brought together), the better the developed systems can work and optimise (route planning, load factors, congestions at terminals or seaports, etc.). Data space business models will be developed and would enable the improved exchange of data (open data, selling data, renting data etc.) to enable the aforementioned (required) sharing and exchange of data, both within IWT and across different transport modes.

On the downside, most of these ideas / projects deal with sensitive data and therefore are limited by one or more of the following issues:

- data availability;
- data ownership and property rights;
- data protection issues and GDPR;
- acceptance of data exchange;
- server storage issues and long-term access of data;
- maintenance of systems using the data;
- etc.

Whilst the progress with data information and exchange should be supported, especially in light of future data-intensive strategies (e.g. Physical Internet), these issues should be properly addressed and integrated in any conceptual framework design.

Section 3.3 also discussed further initiatives such as the ILU-Code register and e-FTI. These initiatives can principally be seen in the aspect of this study as 'enablers' since they help to standardise exchange of information and therefore enable easier exchange of loading units (in case of the ILU-Code) and freight in general (in case of e-FTI). The efforts and time needed to get to practicable solutions in these cases demonstrate that a common (European) solution to any of these standards is not straightforward and can take considerable time (order of magnitude of years).

4.6 Concluding remarks

Throughout the analysis of gaps resulting from the inventory of projects, literature, legislation, ideas as performed in chapter 3, the following observations could be made:

- Most of the relevant technologies discussed are available or can be made available (e.g. alternative fuel, data analysis and exchange, vessel adaptation, etc.);
- Innovative projects and ideas have been developed and are continuously developed (both the financial support and the technological implementation is available);
- The principal EU strategies relevant for inland waterway transport (de-carbonisation, digitalisation, single European market, and modal shift) are followed.

On the other hand, there are still barriers in place which prevent or slow down the implementation of a future-proof inland waterway transport system:

- A clear roadmap for modal shift is missing although the overarching EU (flagship) actions have been communicated (Alternative fuels? Batteries? container sizes? ship dimensions?);
- Different regional boundary conditions exist (e.g. droughts in the Rhine, missing containers and infrastructure in the Danube, etc.);
- Despite the common interest of stakeholders to increase the modal share of IWT, different perspectives still exist according to different perspectives of stakeholders such as a 'river focus' (e.g. Rhine or Danube) , EU focus (EU perspective), country focus (national focus), vessel owner focus, etc.. Any actions could therefore be very different and harmonisation issues might occur. On the other hand, collaboration among stakeholders could be the key for shifting to IWT. The collaboration and types of collaborations could for instance be achieved via bundling, new business models, gain sharing, or other collaboration models;
- Primary focus (certainly by shippers, but not limited to) is still on costs (money rules!) which requires a mind shift (awareness raising), probably only triggered by the right legislative and financial incentives;
- The move to intermodal / multimodal transport is very slow and is based on individual projects focused on the shift from road to rail and the shift from road to inland waterways. Despite the upcoming technologies which will serve as enablers for intermodal / multimodal transport, the sector (together with other transport modes) is not really moving in this direction;
- Up to now, the financial support is insufficient, especially for large investments which cannot be carried by the sector alone. More specifically, there is a lack of support/incentives for road-IWT intermodality, where the road/rail leg is incentivised based on the Intermodal Transport Directive (ITD) where the envisaged revision of the ITD is expected to address this omission;

- Skills of workforce have not been adjusted yet to any of the new developments and upcoming trends[55]; training programmes and awareness rising initiatives have to be launched to increase these skills;
- Shortage of time: if the ambitious EU goals for the sector should be reached according to the envisaged timeline.

The following chapter (chapter 5) will discuss potential measures to overcome these limitations and barriers and chapter 6 will follow up with some final recommendations.

55 Note that WP 3 of PLATINA3 (Jobs and Skills) deals with this topic specifically. In more detail, Tasks 3.1 and 3.2 (standards and refresher classes for zero and low-emission systems, and Tasks 3.3 and 3.4 (onboard-systems for automation) will tackle these points.

5 Market uptake

In chapter 3 an inventory of project works, publication, and innovation has been performed on ongoing R&D actions regarding loading units, transhipping infrastructure, and vessel design and adaptation. Chapter 4 has then looked into gaps on these topics from various viewpoints such as innovation, enablers and barriers, legislation, funding and financing, etc. The purpose of chapter 5 is to first look into the current state of the market (section 5.1) and based on this analysis derive recommendation for follow-up steps to get innovation within inland waterway transport into the market. The necessary steps will be described from the viewpoint of modal shift / intermodal transport (5.2), tools to be developed (5.3), but also incentives related to funding and financing (0), and legislation/standardisation (5.5).

5.1 Current state

During the Green Inland Shipping Event in Brussels (16 October 2019), inland waterway transport was characterised by the following numbers in Europe (see also Figure 6):

- 40,000 km of EU waterways;
- 560 mio. tonnes shipped per year (2019);
- 150 bln. tkm;
- 250 inland ports;
- 6% share of inland freight transport;
- 75% of cross-border traffic;
- Over 42,000 people working on board of a vessel.

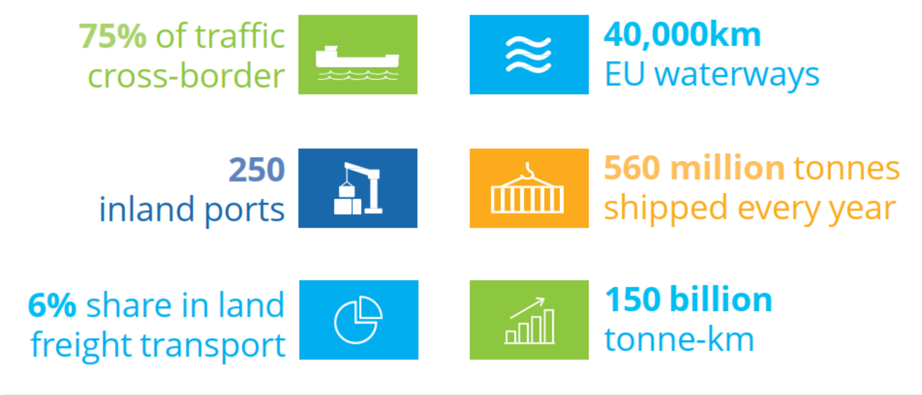

Figure 6. Inland waterways and ports in figures (Source: Green Inland Shipping Event, 2019[56])

The main corridors for inland waterway transport are the Rhine corridor, the North-South axis Netherlands - France, the Danube, and the East-West axis Germany - Poland.

In 2013, the transport volumes were already in the same range (532 mio. tons, see H. De Leijer et al., 2015, see footnote 24) whereas country shares of IWT against other transport modes differ quite significantly, e.g. The Netherlands (67%), Germany (40%), Belgium (36%), and France (13%).

[56] Green Inland Shipping Event, Brussels, 16 October 2019, available via Inland Navigation Europe, https://www.inlandnavigation.eu/

The recent CCNR thematic report on new markets[57] provides statistics on the cargo transported (IWT volume in EU-27 in 2020) as follows:

- bulk transport (59.8%)
  - Agricultural products
  - Feedstuff and food products
  - Iron ore, steel and metals
  - Sand, stones, gravel and building materials
  - Coal
- Liquid cargo (28.1%)
  - chemicals
  - petroleum products
- Containers (12.1%)

Observed trends in these numbers are diverse and range from positive trends (e.g. in construction materials or chemical products), partly positive (depending on geographical region, e.g. for steel and iron ore in Eastern Europe or on local production, e.g. food production), stagnating (petroleum products but with uncertain future due to increasing greening and use of batteries), and decreasing (e.g. coal as a consequence of the Paris Agreement of the UN or containers).

These trends come from different drivers, some of them global such as the pandemic, a shift from goods to services, less global trade due to less wages and cost differences across the globe, e-commerce, invention of 3D printers, declining population growth (in Western Europe), etc. Some other reasons are more local like the transport in cities or food transport.

The trend for more population in cities (with at the same time a saturation of transport infrastructure there), the unsaturation of inland waterway transport compared to other modes, the lack of congestion, and the relative low costs of transport are opportunities for IWT.

The overall share of inland waterway transport as compared to other modes has not dramatically changed in the different countries and in general. Also, the cargo transported does not see significant variations of numbers over the past years. Despite the favourable conditions for transporting cargo via inland waterway, a modal shift has not taken place yet and the sector remains rather inert to any changes. Therefore, the next sections will discuss the reasons and potential actions to overcome the inertia of the sector.

5.2 Modal shift and intermodal transport

5.2.1 Modal shift

Rodrigue (2020), see footnote 48, has sketched the process of modal shift as shown in Figure 7 in which the modal shift from a transport mode to another is shown over time, very often covering three phases:

- Inertia phase
- Modal shift phase
- Maturity phase

[57] https://inland-navigation-market.org/chapitre/1-setting-the-scene-what-is-the-situation-today/?lang=en

The comparative advantages mentioned in Figure 7 could be of different types such as costs, capacity, time, flexibility, or reliability. Usually, it requires the comparative advantages to be significant before companies take initiatives to perform a modal shift.

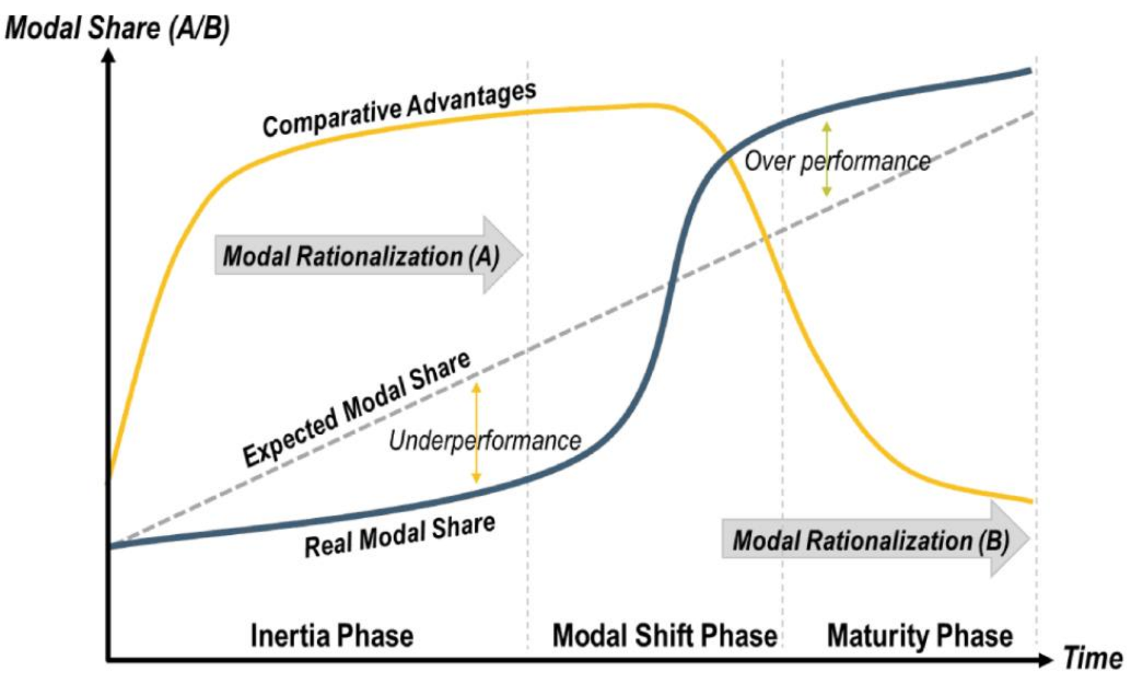

Figure 7. Principles of modal shift (source: Rodrigue, 2020, see footnote 48)

Numbers to shift from (e.g.) road to IWT are very much in favour of IWT: one inland (container) vessel can replace, depending on size, in between 14 and 660 trucks, reduces fuel consumption and carbon emissions by about 60% to 80% and noise by about 50% to 75%, and is more reliable due to less or no congestions on waterways. On the other hand, it has also been discussed that very often the shift is only triggered when larger distances have to be covered which may typically be more than what can be done by a truck during one or two days. Also, it depends on the connections for the 'last mile' and easiness to transfer the cargo to other modes of transport.

Form this, although very simple, observation, it can already be concluded that the comparative advantages to shift to IWT are not, or are not seen, sufficient enough to perform the shift. Actions to trigger the shift could therefore be, but are not limited to:

- raise awareness of advantages of inland waterway transport by information campaigns;
- provide tools to calculate the advantage of a shift (business case);
- provide maps and comparative calculators for transport which allow to either book IWT directly or combine it with different transport modes;
- trigger an agreement on universal loading unit(s) for intermodal transport and to be used across different transport modes and the 'last mile' (see section 5.2.2 below);
- provide a scale for 'measuring' advantages of inland waterway transport (costs per tkm, CO_2 and GHG emissions, etc.)
- stimulate modal shift by legislative and financial incentives, both national and EU-wide;

5.2.2 Intermodal transport

Intermodal transport as understood in this report is the movement of freight from an origin to a destination relying on at least two modes of transportation. Each carrier is issuing its own contract. Transfers from one mode of transport to another are commonly taking place at specifically designed terminals. Therefore, intermodal transportation refers to an exchange of freight between two transportation modes[58]. The key elements of intermodal transportation are therefore:

- Composition;
- Transfer;
- Interchange;
- Decomposition.

In simple terms, the necessary 'elements' need to be in place to perform all the relevant operations for intermodal transportation, such as:

- loading units to be used in different transport modes;
- infrastructure for composition, interchange, and decomposition;
- (digital) data availability, visibility, and exchange during transportation;
- (re-skilled) workforce available to perform the relevant operations;
- mind shift with respect to no longer think in 'silos' but in terms of common 'win-win' scenarios;
- flexibility of elements to react on market needs and changes.

From the gap analysis summarised under section 4.2, finding a common **loading unit** would require:

- needs analysis for European waterways (and beyond), units need to be compatible to constraints from different transport modes and infrastructure;
- agreement of all stakeholders within IWT and across different modal transports on one or several loading units fulfilling the aforementioned requirements;
- adaptation of standards and regulations to allow loading units to be used across EU;
- re-skilling of workforce for transport, handling, and transhipment of loading units.

An alternative option rather than developing a new loading unit, could be the option to develop a **standardised handling system** which can deal with existing loading units (no change of units required) and overcome the disadvantages of dealing with non-uniform and non-standardised units (loose goods, pallets, semi-trailers, swap bodies, etc.). The Austrian Danubia-Kombi concept could be such an example, see footnote 160. However, also for such a system, the same or very similar requirements as mentioned for the loading units before, would apply as well.

As for the **transhipment infrastructure**, the gap analysis has shown that there are barriers potentially preventing new infrastructure to be put in place (costs, space requirements, lack of agreements on units, regulations, etc.). However, new options are resulting from ICT developments, remote controlling, and automation. Due to large investment efforts for new infrastructure, modifications or adaptations of existing ones might be the preferred solution, if they are in line with developments of the loading units. Further developments in ICT and automation will allow (standardised) infrastructure to operate with (standardised) loading units faster and more efficiently than before, minimising transhipment times and costs.

Availability of **data** for the whole supply chain is a key prerequisite of intermodal transport. Data need to be available throughout the supply chain to all relevant stakeholders. Registration tools, databases,

[58] For comparison: multimodal transport is understood here as technically the same mode of transport with the key difference that only one contract is issued.

and codes are being developed and will become more and more available in the future. Regulations will support these developments such as the ILU-code register and the e-FTI regulation. These trends need to be supported so that a consistent availability and use of data for intermodal transport becomes a reality.

A revision of the Intermodal Transport Directive (ITD) will be needed to accommodate the aforementioned changes of elements and/or new suggestions. In addition, it would be helpful to incentivise the road-IWT leg with e.g. transshipment costs.

Last, but not least, any modification or change will require a **re-skilling of the workforce** performing the transportation processes, on the composition and de-composition side, the transfer, and the transhipment side. The necessary and relevant training and teaching modules and programmes need to be developed, the know-how of teachers (from industry) to be gathered, and the relevant certificates to be discussed and issued. All this will require a significant effort and authorities to be involved, especially when certificates are EU-wide and can be used across various countries.

5.3 Tools

Internet-based information and tools would certainly assist many stakeholders in the sector to perform a shift from road to inland waterway transport or to intermodal transport. The key issues with internet-based information and tools are i) how to find it, ii) be up to date, iii) be objective and informative without selling someone's products or services, iv) be responsive to sector modifications, v) address several audiences (public, stakeholders, policy makers, etc.), iv) be available in different languages. Information can comprise, but is certainly not limited to:

- general information about inland waterway (transport);
- news about changes (waterway network, vessels, propulsion, fuel, etc.);
- news about standardisations, regulations and policies (in different countries);
- information about financing opportunities and subsidies (for projects, for vessel owners, for shippers, and other stakeholders), see e.g. the European funding overview at https://eibip.eu/funding/.

Note: much of this information is available already but not always straightforward to find. Depending on the host of the information, there is always a (biased) focus on potential clients or interest groups. Whilst this is more than understandable, the sector would certainly benefit from unbiased information which also looks across borders, considering the whole (European) waterway network, and also provide links to other transport modes and/or inter-/multi-modal transport.

Tools may comprise all sort of services, either internet-based or on a smartphone, which could comprise:

- **Calculation of business cases** for companies, shippers, freight forwarders for specific projects or in general. The outcome would indicate whether or not a shift to inland waterway transport or intermodal transport is technically and economically feasible.
- **Freight navigation calculation**: which is the best route for freight to be transported using inland waterway transport or complimentary transport modes, see example for inland waterway transport on Route Search Engine (blueroadmap.nl).
- **ETA prediction** calculations: what is the expected time of arrival of freight at which location? Using information from the location of vessels, waterway network conditions, infrastructure, etc. a prediction of ETA can be made similar to any car or truck navigation system on a road.

- **Track-and-trace** tools for your freight: in addition to ETA tools, track and trace systems allow to provide more details on where freight is located currently. Whilst this is technically doable for vessels already (and already done in the maritime sector), it may be more difficult at the moment for smaller cargo units (pallets) although systems are in preparation and it remains a question of (short) time until the technology is market ready.
- **Simulation of freight transport tools**: if digitalisation becomes more widely available and accepted (see e.g. scenarios within Physical Internet), different routes and transport modes can be simulated regarding time, costs, infrastructure use, etc. This would allow stakeholders to easier and better decide on options in case of any network-related or infrastructure-related issues.
- **Congestion avoidance tools**: similar to simulations, these tools would allow to predict and suggest alternative routes in case of sudden congestions (although not too likely on inland waterway transport routes) due to waterway or infrastructural issues.
- **Waterway and infrastructure network information tools**: permanent information on the waterway conditions (e.g. water levels, fairway conditions, lock operations, port congestions will be possible once ICT and IoT based technology is available and installed. In a second stage, this information would be needed to allow for either remotely –controlled, partially automated vessels on inland waterways.
- **Freight cost calculation** for inland waterway transport: More detailed information from the stakeholders involved in inland waterway transport will allow tools to predict the freight transport costs and compare it to other transport modes. All these tools will eventually form a decision support system for freight transportation on inland waterways. Costs will be calculated in units which are directly comparable to other modes, also including emission costs (CO_2, GHG, etc.).
- **Smart mobility tools:** smart mobility will be the future way for mobility of freight in Europe and first projects and ideas are on the way and working (see e.g. section 0). These systems will allow for better planning of transportation, less congestions at hubs, better use of loading units (e.g. idle time of containers), higher load factors, and more data for everyone's availability. They will therefore contribute to higher efficiencies, more capacity, and fewer emissions.

It should be noted that many of these tools are available already within private and public (passenger) transport, traffic information systems, etc. Therefore, no larger technical developments are needed to provide these tools even though the potential end-users of such products might be a lot less than for passenger transport.

The set-up of information and tools could be part of the work of an independent task force or organisation which looks into all the relevant aspects of market uptake as discussed within this chapter. Providing information and tools, raising awareness, maintenance of and dissemination of websites and tools are time-consuming tasks which also require a wide range of skills and personnel. This aspect will be further discussed in chapter 6 of this report.

5.4 Financial incentives

The sector will face significant changes in the future, all of which will be needed to remain competitive in the market. These changes comprise, among others:

- use of alternative fuels and adaptation of the fleet and engines towards new propulsion systems and fuels;
- electrification, incl. adapted propulsion systems and the use of batteries;
- digitalisation, new data-oriented, and smart technologies resulting in more automation of vessel movements, transhipment infrastructure, and waterway infrastructure;
- shift to intermodal and multi-modal transportation, including use of new or adapted transhipment hubs

It remains clear from the inventory in chapter 3 and the gap analysis in chapter 4 that the sector cannot finance these changes alone. Smaller investments, especially when resulting in a positive business case, will certainly be carried by the sector but large-scale investments remain difficult. Without those, however, the sector will not be able to fully move away from traditional ways of transport and thinking. An analysis of the European market has to be performed showing the volume of financial incentives which will be needed for the sector to move faster towards new business and operational models, including the full implementation of modal shift. A clear roadmap for the modal shift[59] has to be developed, building upon and at the same time filling in the gaps of the main existing initiatives[60]. Particular attention will have to be paid on which additional investments in which assets will happen at which point in time.

5.5 Legislative and policy incentives

Legislation has proven to be an excellent incentive for moving a sector or market in a certain direction. Without the EU rules and legislation for a Single Market or for the Green Deal, hardly any movements would be seen in the various transport & mobility sectors.

However, before moving into any (new) direction, the definition and semantics of where to move should be made very clear. Still until today, different definitions are used for intermodal and multimodal transportation, partly depending on the geographical origin though, which makes global or continent-wide regulations cumbersome.

On a global and European scale, every change of the sector will need new - or more likely modified - regulations to assure the same conditions across the geographical reach of the regulation. It is therefore expected that (at least) the following regulations, related to the objectives of this deliverable, will either be still needed or adapted:

- regulations of inland waterway vessels taking into consideration any future changes of vessels (electrification, alternative fuels, climate adaptation, new loading units, digitisation, etc.);
- regulations for new or modified transhipment infrastructure with the aim to reduce transhipment costs;
- a regulatory framework for a tiered approach towards intermodal and multimodal transport;
- regulations for the collection, access, storage, security, and use of data (GDPR and beyond);
- regulations to force shippers and brokers to report their use of transport modes which could be used for steering further political decisions;

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59 See also the CCNR roadmap for reducing inland navigation emissions, https://ccr-zkr.org/files/documents/Roadmap/Roadmap_en.pdf

60 Like the TEN-T corridors or the national Recovery and Resilience Plans

- regulations for operating unmanned and automated vessels on waterways;
- regulations for remote-controlled and automated infrastructure assets for transhipment;
- regulations for workforce operations;
- revision of ITD (see earlier)

Once the aforementioned roadmap for a future inter-/multimodal transportation is developed, a full list of regulations (and standardisation) has to be drafted and agreed. Given the average duration of ordinary legislative procedures at the EU[61] (average of 40 months for procedures where adoption of the legislation takes place in the second reading, during the 2014-2019 legislative term, average of less than 18 months for proposals adopted in first reading) it will already be close to have legislations in place before 2030. Any incentives in this direction will therefore have to start as soon as possible and will have to indicate at a very early stage the details of what will be regulated.

The NAIADES III action plan (Communication COM(2021) 324)[62] shows already a comprehensive list of actions for inland waterway transport, including modal shift (8 actions), decarbonisation (14 actions), digitalisation (5 actions), workforce adaptations (5 actions), funding (1 action) and governance (2 actions). Some of these actions are rather specific and refer to an existing regulation, others are less detailed and need further detailing and specifications. It is also clear from the number of actions in each of the flagship activities where the current priorities of the Action Plan lies.

These Action Plans are needed to initiate movements of the sector, but will not work alone without the legislation being drafted or agreed nor will work without any financial stimulation. Furthermore, the aforementioned actions focus on inland waterway transport and not on intermodal or multimodal transport which require additional actions, also across different modes, e.g. a revision of the combined transport directive.

Action Plans should also address the roles of stakeholders for reaching the specific goals. Without specific tasks and obligations for each stakeholder involved in IWT, none of the envisaged goals can be reached. This comprises not only regulations and laws, but also voluntary actions. These could comprise, but is of course not limited to, actions of shippers and brokers in pilot projects to demonstrate the advantages of intermodal transport, initiatives by regulatory bodies to scan logistics processes and optimise them, and so forth.

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61 https://www.europarl.europa.eu/infographic/legislative-procedure/index_en.html#:~:text=The%20average%20length%20of%20the,second%20reading)%20was%2040%20months.

62 https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:324:FIN

6 Recommendations

The following recommendations can be drafted from the analysis performed in this report with a clear focus on loading units, modal shift, and vessel adaptation. Some of these recommendations are in line with the priorities already defined in the EIBIP report, see footnote 20, on innovation uptake in inland waterway transport, and are also part of the NAIADES III and 'Sustainable and Smart Mobility' Action Plans.

6.1 Roadmap

The plan where to go and which tools and methods to use needs to be drafted until at least 2050. This "Roadmap for Modal Shift and Decarbonisation" needs to address the modal shift and needs to be fully integrated in the logistic chain. Even though this deliverable barely touches on emissions, the title of the roadmap includes 'decarbonisation', too, since modal shift will not be feasible without moving to low or no emission vessels. The decarbonisation topic will be discussed in more detail in other deliverables of PLATINA3 (e.g. D1.1). Furthermore, the roadmap needs to specify which loading units to build on, which transport modes to use for which type of transport, which infrastructures to develop, which incentives to put in place, etc. Without such a roadmap, there is a risk that too many technologies will be developed (and abandoned later) and that too much time is lost to reach the overall objectives. The roadmap has not only to specify the ways to go but also the methodological details of these actions, including the developments, tools, and incentives which need to be prepared.

6.2 Mind shift

Without a fundamental change in the way inland waterway transport and other transport modes are structured and managed, the individual transport modes will only change marginally, and a modal shift or intermodal/multimodal transport is unlikely to happen fast enough if at all. This mind shift will have to be triggered by awareness campaigns (within all stakeholder groups), but also financial, regulative, and policy incentives, and demonstration examples, all of which take a considerable time and will need to start immediately.

6.3 Incentives

Incentives comprise financial, legislative, and policy incentives but also availability of tools which help to initiate the shift to inland waterway transport or - preferably - intermodal/multimodal transport. Tools will have to be built based on higher availabilities and access of (large) data across all transport modes, registered loading units, vessels, routes, hubs, infrastructure, etc. which will be available to all stakeholders of the supply chain process. This will need standardisation procedures for (the use of) data, ownership rights amendments, and security regulations. Some of these incentives have been discussed in sections 0 to 5.5 already.

There is a risk that the aforementioned shift will not have happened until 2030 unless a significant additional push in this direction is initiated. The role of the public, governmental authorities across Europe, and public-private partnerships will be crucial to make the shift happen. A key effort will be to overcome the 'individual transport mode' (= silo) thinking to optimise (freight) transport across all existing and future transport modes.

The vision here is that incentives help to make the shift happen by supporting the individual steps drafted in the roadmap (section 6.1). The right incentive(s) will be used, and the role of public bodies and decision makers will remain to trigger and steer the transport sector in the desired direction.

6.4 Vessel adaptation

Vessel adaptation is not limited to the adaptation of the vessel itself, but also includes the fuel / batteries to be used, adaptation of the propulsion system, and any other modification, e.g. in the context of data collection, ship manoeuvring, etc. Developments, projects, and demonstration examples have started here already, but most of them looking into either smaller changes (e.g. energy savings by ship hull modification or alternative fuel usage). Once the roadmap and the necessary incentives have been defined, vessel adaptation will also have to consider any adaptation to new/modified loading units, vessel equipment, and digitalisation consequences. Since time is becoming more and more of the essence, stakeholders need to be 'convinced' that they all need to pull the same strings rather than competing in the best way to reach the goal.

6.5 Infrastructure

'Infrastructure' means the transhipment infrastructure which is needed for the composition of the freight (from the first mile), for the interchange at certain hubs, and for the de-composition of freight to the last mile transport. This will include storage capacity of loading units once they are not in use. It also refers to any installations needed for batteries (charging stations, exchange of batteries, storage, etc.) or alternative fuels (bunkering). Depending on the roadmap and the vessel adaptation, this infrastructure needs to be adapted at the central hubs which are planned without ignoring that there is still a significant freight transport (at least for inland waterway transport) through traditional forms of transportation e.g. bulk transport or (chemical) liquids.

The vision is that inland waterway vessels sail in between hubs which are fully or partially equipped to operate the smooth transport of freight using the best suitable (in terms of costs, emissions, time, etc.) mode of transport. Due to optimised data flows, shippers and vessel owners have permanent access to data showing where the freight is located and when it will arrive. Re-routing due to unforeseen events will be possible at any time providing alternative routes in real time. In addition, the congestion problem in container handling in seaports will have been solved so that container transport is no longer hampered by this issue.

These recommendations are summarised in Figure 8 where each element of the figure is one of the recommendations described before.

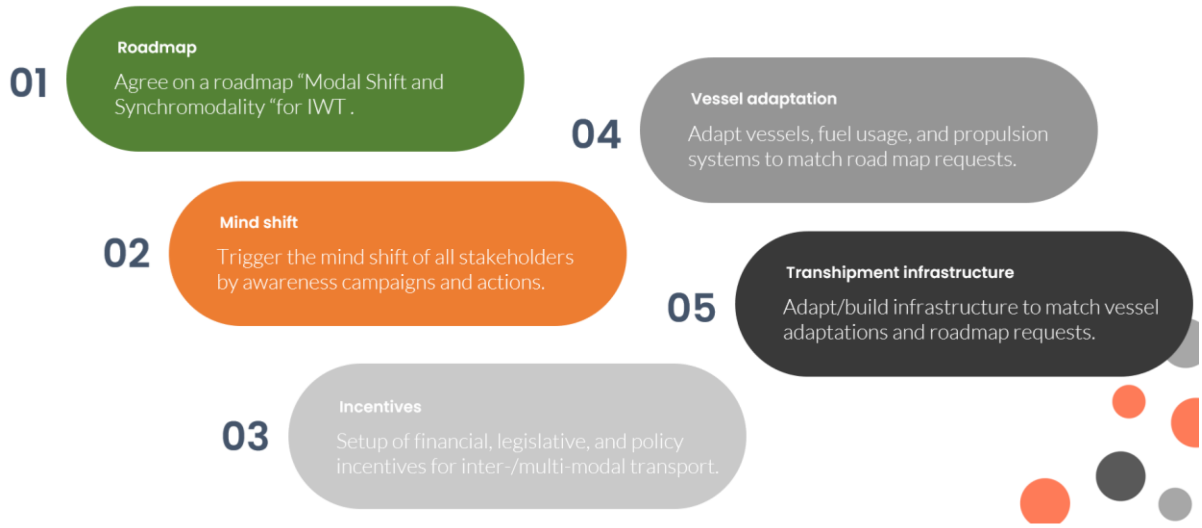

Figure 8. Five key recommendations for market uptake of shift to intermodal / multimodal transport

Annex A: Project overview

Closed Projects

UTI-NORM

The UTI-NORM[63] project (1998-1999) was an European funded project under FP4-TRANSPORT, looking into the 'Current State of Standardisation and Future Standardisation Needs for Intermodal Loading Units'. It investigated the state of standardisation of intermodal transport units and aimed to find a standard for the future European loading unit. The study[64] suggested a European loading unit overcoming the shortcomings of containers (ISO 668 and 1496) and swap bodies (CEN).

SPIN-TN

The SPIN (Strategies to Promote Inland Navigation) Thematic Network, SPIN-TN (2002-2005)[65], was funded under the 5th Framework Programme (FP5-GROWTH-KA2 - Sustainable Mobility and Intermodality) and aimed to develop a Common European Strategy to increase the share of inland navigation in the transport of goods and to encourage the acceptance and implementation of the strategy. It has looked into the freight market and the influential factors of the logistics performance of the inland waterway system according to technical, physical, and organisational characteristics.

TELLIBOX

The EU-funded (FP7-TRANSPORT) project TELLIBOX (Intelligent MegaSwapBoxes for Advanced Intermodal Freight Transport, 2008-2011)[66] aimed to achieve an all-purpose, intermodal loading unit that is applicable to transport via road, rail, short sea, and inland shipping. The advantages of containers and semitrailers were combined by a MegaSwapBox. Challenges facing the development were that the MegaSwapBox had to:

- be trimodal,
- be stackable and applicable for handling from the top,
- use existing low floor wagons for rail transport,
- provide an adaptable chassis for road transport,
- have an optimised cargo volume of $100m^3$ with an internal height of 3m,
- have loading facilities from three sides (completely openable doors),
- offer improved safety features against pilferage.

The team tested prototypes and optimised their design on a defined intermodal corridor from Poland, via Germany, and the Netherlands, to the United Kingdom using rail, train, road, and short sea shipping. The TELLIBOX concept was ready to be put into wider use and the project also created a strategy to exploit the innovative technologies and maximise uptake.

63 https://trimis.ec.europa.eu/project/current-state-standardisation-and-future-standardisation-needs-intermodal-loading-units

64 Bureau International des Containers et du Transport Intermodal (BIC) (1999). Current State of Standardisation and Future Standardisation Needs for Intermodal Loading Units in Europe, UTI-NORM, 185 pp.

65 https://trimis.ec.europa.eu/project/strategies-promote-inland-navigation

66 https://cordis.europa.eu/project/id/217856

PLATINA

PLATINA[67] (Platform for the implementation of NAIADES, 2008-2012) was a coordination and support action aimed at the promotion of inland waterway transport (IWT). The main objective of PLATINA was to support the Commission, Member States and third countries in the implementation of the NAIADES action programme. This was achieved by providing technical, organisational, and financial support for targeted policy actions and by building on strong interrelations with existing expert groups, projects, and initiatives.

WP1 (Markets) aimed at awareness raising on the possibilities offered by IWT, by identifying best practices, contributing to an improved administrative and regulatory framework, and by developing a European IWT information portal. WP2 (Fleet) supported European IWT innovation by assisting in technology assessment, providing incubation assistance to speed up market transfer of innovations, raising visibility of IWT on strategic research agendas, facilitating exchange of hull-related information. WP3 (Jobs & Skills) was about raising awareness on career opportunities in IWT, foster mutual recognition of qualifications, and support the implementation of harmonised education curricula. WP4 (Image) coordinated activities relevant to the promotion of IWT at European level, extend and deepen the existing network of promotion and development agencies, and will prepare a common communication strategy. WP5 (Infrastructure) supported the creation of a European development plan for the improvement of IWT infrastructures, supported the implementation of River Information Services, as well as the inter-disciplinary dialogue on environmentally sustainable waterway development.

EWENT

The EWENT project[68] (Extreme Weather impacts on European Networks of Transport, 2009-2012) addressed the EU policies and strategies on climate change with particular focus on extreme weather impacts on the EU transportation system. The goal of EWENT was to estimate and monetise the disruptive effects of extreme weather events on the operation and performance of the EU transportation system. The methodological approach was based on generic risk management framework that followed a standardised process starting from the identification of hazardous extreme weather phenomena, followed by impact assessment, and concluded by mitigation and risk control measures. In detail, the project:

- Identified and defined the hazards on EU transportation systems caused by extreme weather phenomena and develop relevant scenarios.
- Estimated the probabilities of harmful scenarios caused by extreme weather
- Estimated the consequences of extreme weather events based on developed scenarios, first on EU transport infrastructure, then on operations and finally on supply chains and mobility.
- Monetised the harmful consequences per transport mode both on infrastructure and operations (including mobility and supply chain impacts).
- Evaluated measures and options for negative impact reduction, control and monitoring in short and long-term.
- Analysed different management and policy options and strategies.

EWENT covered most transport modes (including passenger & freight): road, rail, aviation, waterways, and light (pedestrians, cycling). The transport system was viewed from three angles: infrastructure,

67 https://cordis.europa.eu/project/id/218362
68 https://cordis.europa.eu/project/id/233919

operations, and indirect impacts to third parties. EWENT evaluated the efficiency, applicability, and finance needs for adaptation and mitigation measures which helped minimising the costs of extreme weather impacts.

ECCONET

The objective of ECCONET[69] (Effects of Climate Change On the inland waterway and other transport NETworks, 2010-2012) was to gather the expertise of partners from different fields related to meteorology, hydrology, infrastructure operation, transportation, and economics to assess the effect of climate change on the transport network, taking the inland waterway network as a case-study. The project was based on consolidation and analysis of earlier and existing research work as well as application of existing climate change and hydrological assessment tools for evaluation of climate change effects on the inland waterway transport (IWT) network.

The project initially evaluated recent climate change scenarios, leading to predictions on the weather conditions in the future. Naturally, these resulted in changes of the hydrological balance of the inland waterway network, being either associated with less ice formation and more balanced waterway conditions over the year or extreme situations such as prolonged low water periods or floods, depending on the region considered.

The effect of these changes was then assessed on the costs and reliability associated with inland waterway transport and other transport modes, which might lead to changes in transport flows. These calculations formed the basis of a baseline scenario, assuming little or no deviation in policy related to IWT or other transport modes.

STREAMLINE

The STREAMLINE project[70], [71] (2010-2014) focused on the radical improvement of ship propulsion systems with three main objectives:

- demonstrate radically new propulsion concepts delivering an increase in efficiency of at least 15% over current state-of-the-art. The concepts were designed for maximisation of energy conversion combined with low levels of cavitation, noise, and vibration. The research looked at novel applications of large area propulsion, a biomechanical system and distributed thrust (via multiple propulsors).
- investigate methods to fully optimise current SoA systems including conventional screw propeller systems, pods, and waterjets. The key here was exploitation of new CFD methods to pursue improvements without dramatic vessel configuration changes.
- develop advanced CFD tools and methods to optimise the hydrodynamic performance of the new propulsion concepts, particularly by analysis of integrated hull and propulsor.

MoVe IT!

The MOVE IT! project[72] (Modernisation of vessels for inland waterway freight transport, 2011-2014) project was established to develop options for the modernisation of inland ships. The solutions were

69 https://cordis.europa.eu/project/id/233886
70 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/streamline
71 https://cordis.europa.eu/project/id/233896/reporting
72 https://cordis.europa.eu/project/id/285405

subjected to an environmental assessment and carried out on five vessels. They comprised a container vessel, three pushers and a motor cargo vessel that was operated together with a lighter.

An overview of selected retrofit options showed that vessel owners expressed little interest in power-related retrofits, because emission abatement techniques such as filters and catalysts can only lead to very limited fuel savings. In addition, they can sometimes result in an increase in fuel consumption, while there are little to no other economic benefits.

Other solutions like liquefied natural gas, compressed natural gas, fuel cell, diesel electric or all-electric propulsion all require major modifications to the engine room and large investments, which also makes them unattractive business-wise. Also, it appeared from the choices of the shipowners that apparently there is no universal desirable retrofit solution for inland ships.

Therefore, MOVE IT! developed guidelines that can be used by shipowners when considering vessel improvements and were published in an easily accessible format for ship operators and shipowners. They include hydrodynamic improvements, efficient ship operation, powering the vessel and engines, ship structure and weight, and new scale and service.

MOVE IT! showed that modernisation of inland vessels needs a customised approach, which takes into account both the economic viability and the environmental sustainability of IWT. It also highlighted the need for further development of relative low-cost mathematical tools for the different types of analysis needed in assessing available options.

MODULUSHCA

The European funded MODULUSHCA project[73,74] aimed to achieve the first genuine contribution to the development of interconnected logistics at the European level, in close coordination with North American partners and the international Physical Internet Initiative. The goal of the project was to enable operating with developed iso-modular logistics units of sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG), providing a basis for an interconnected logistics system for 2030.

Two of the five working fields of MODULUSHCA comprised the development of a set of exchangeable and interlocking (ISO) modular logistics units (M-boxes) providing a building block of smaller units, and the establishment of digital interconnectivity of these units.

NEWS

The European NEWS project[75] (Development of a Next generation European Inland Waterway Ship and logistics system, 2013-2015) has looked into the increase of cargo flows along the Danube by transforming ports into logistics centres and efficient terminals. The project conceived a new vessel type to minimise carbon dioxide emissions from container transport and make transport links across continental Europe more accessible, addressing bottlenecks along the major freight route Rhine/Meuse-Main-Danube.

To achieve its aims, project members defined the concept and validated the technical specifications of a novel inland waterway container ship. They designed ship hulls to enable efficient container

[73] https://cordis.europa.eu/project/id/314468
[74] Huschebeck, M. (2016). "MODULUSHCA - Project Final Report", MODULUSHCA - Modular Logistics Units in Shared Co-modal Networks, PTV Group, 20 pp.
[75] https://cordis.europa.eu/project/id/314005

transport in shallow and low-level waters, as well as an electric propulsion system that uses alternative energy sources and fuels. The vessel was designed to boost resource efficiency by up to a third and lower harmful exhaust emissions from ships. Although the new vessel design was very promising, the return on investment was too low to make it commercially viable. Nonetheless, the project team has outlined a series of recommendations and logistics approaches to streamline inland waterway cargo transport.

The Upper Danube between Germany and Hungary was identified as the most promising area to operate the system. In this context the team analysed the target area's logistical network and integrated the vessel into intermodal transport chains within the Danube Region. This facilitated the assessment of current transport chains and the planning of potential new ones with the system.

PLATINA II

PLATINA II[76] (Platform for the implementation of NAIADES, 2013-2016) followed PLATINA and was a Coordination Action aimed at the implementation of the NAIADES Action Areas. PLATINA II built on the results of PLATINA (2008-2012) and was in line with the NAIADES action programme. It aimed at bringing together key stakeholders in order to ensure a solid, multidisciplinary knowledge basis for the implementation of NAIADES actions. PLATINA II, in close cooperation with the European Commission, set up a roadmap for the implementation of actions and supported permanent-type actions.

LNG Masterplan for Rhine/Meuse-Main-Danube

The EU-funded LNG Masterplan project[77, 78] (2013-2015) was jointly coordinated by Pro Danube Management GmbH (Austria) and Port of Rotterdam Authority (Netherlands), and united 33 partners from 12 countries and one associated partner from Switzerland. The key objective was to facilitate the introduction of LNG as fuel and as cargo for European inland shipping.

The project has delivered several studies and more than 60 deliverables with respect to markets, technologies, end-users, safety, regulations, and financing as well as terminal and vessel solutions, pilot deployments, and a strategy document.

RPIS

The CEF funded RPIS project[79] (RheinPorts Information System, 2014-2018), aimed to develop an innovative IT platform for the upper Rhine ports allowing centralised coordination and efficient traffic organisation. This takes the form of an integrated and interfaced system with the IT-software of terminal operators, barge operators, customs services, and river information systems.

The results expected from the introduction of the platform were:

- Improving logistics processes along the Rhine as a central corridor of the trans-European transport network (TEN-T)
- Increasing the competitiveness of inland waterway transport vis-à-vis rail and road.

[76] https://cordis.europa.eu/project/id/321498

[77] www.lngmasterplan.eu

[78] Seitz, M. (2015). Liquefied Natural Gas - Fuel and Cargo for Inland Navigation, LNG Masterplan Rhine-Main-Danube, 70 pp.

[79] http://www.upper-rhine-ports.eu/en/our-projects/cef-project-upper-rhine-ict-traffic-management-platform.html

- Reducing CO_2 emissions through a reduction in vessel waiting times and an increase in the load rate of river units.

To achieve these objectives, the step-by-step development of an IT platform has been realised, of which a pilot version was first introduced at the level of the RheinPorts (Basel-Mulhouse-Weil am Rhein) with their seven container terminals.

Since May 2015, the RheinPorts Information System (RPIS) has been operational for all parties involved (particularly for barge operators and terminal operators). A second stage of the project has been a feasibility study for the introduction of the system in six other ports along the Upper Rhine (Colmar/Neuf-Brisach, Strasbourg, Kehl, Karlsruhe Mannheim, Ludwigshafen), preparing the deployment of the IT platform with local adaptations. In a third phase, a study of possible functional extensions of the system and geographical extensions beyond the Upper Rhine has been carried out.

#IWTS2.0

Inland Waterway Transport (IWT) offers relatively slow, cheap, climate friendly hinterland transport alternatives for commodities transported in large quantities or bulk. The energy input per t/km is superior to rail, road transport. #IWTS2.0[80] (Inland Waterway Transport Solutions 2.0, 2014-2020) addressed the following challenges:

- Low awareness about small waterway transport opportunities;
- Low innovation in small barge development, transhipment of goods;
- Lack of expertise in using small waterway opportunities;
- Lack of training content and dedicated crews for small waterway sailing.

The #IWTS2.0 approach comprised:

- Realising a quick modal shift by introducing new and proven logistic technologies and support logistic managers that decide about modal shifts;
- Make better use of existing waterways by adapting them towards sufficient standard-sized vessels;
- Make better use of existing waterways by developing innovative sustainable small barge concepts.
- Modernizing IWT education, training with a focus on navigation on smaller waterways.
- Showcase proven concepts by piloting 8 small waterway modal shifts including solutions for innovative barges, waterways, transhipment, (un)loading, freight flow mapping, and modal shift.

HERCULES-2

The HERCULES-2 project[81, 82] (2015-2018) was targeting at a fuel-flexible large marine engine, optimally adaptive to its operating environment. The objectives of the HERCULES-2 project were associated to 4 areas of engine integrated R&D:

- Improving fuel flexibility for seamless switching between different fuel types, including non-conventional fuels.
- Formulating new materials to support high temperature component applications.

80 https://northsearegion.eu/iwts20/about-iwts/

81 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hercules-2

82 http://www.hercules-2.com/

- Developing adaptive control methodologies to retain performance over the powerplant life-time.
- Achieving near-zero emissions, via combined integrated aftertreatment of exhaust gases.

HERCULES-2 was the next phase of the R&D programme HERCULES on large engine technologies, which was initiated in 2004 as a joint vision by the two major European engine manufacturer groups MAN and WARTSILA. Three consecutive projects namely HERCULES - A, -B, -C spanned the years 2004-2014.

By combining cutting-edge technologies, the project aimed at significant fuel consumption and emission reduction targets using integrated solutions, which could quickly mature into commercially available products. Focusing on the applications, the project included several full-scale prototypes and shipboard demonstrators.

PROMINENT

The PROMINENT project[83, 84] (Promoting Innovation in the Inland Waterways Transport Sector, 2015-2018) addressed the key needs for technological development, as well as the barriers to innovation and greening in the European inland navigation sector. PROMINENT thereby was fully in line with the objectives of the European action programme NAIADES-II. PROMINENT ultimately aimed at providing solutions which make inland navigation as competitive as road transport in terms of air pollutant emissions by 2020 and beyond. In parallel, PROMINENT aims to further decrease the energy consumption and carbon footprint of IWT, an area where IWT has already a strong advantage compared to road transport.

PROMINENT focused on:

- Massive transition towards efficient and clean vessels.
- Certification and monitoring of emission performance and development of innovative regimes
- Harmonisation and modernisation of professional qualifications and the stimulation of the further integration of IWT into sustainable transport chains.

PROMINENT achieved the following targets:

- develop cost-effective solutions applicable to 70% of the fleet and reduce the implementation costs by 30%;
- involve all relevant stakeholders;
- actively address and remove implementation barriers by 2020.

PROMINENT identified barriers and facilitating factors for innovation uptake of alternative fuels for IWT which were identified based on desk research and expert knowledge within the PROMINENT consortium.

According to this study, the following generic barrier categories or failure factors were identified:

1. Technical (immaturity of technology or lack of operational requirements),
2. Legal (unadjusted legislation),
3. Financial (access to capital or business case),
4. Knowledge (lack of expertise or skills),
5. Market (structure, conditions,…) and

83 https://cordis.europa.eu/project/id/633929
84 https://www.prominent-iwt.eu/

6. Cultural (conservatism, old habits).

PROMINENT concluded that LNG, dual fuel, Stage V engines and hybrid propulsion with buffer battery were technologies confronted with the highest barriers. Technologies that faced the lowest barriers were GTL fuel, CCNR II engines and SCR technologies. There were also substantial differences acknowledged between different vessel types. Overall, 14 technologies were identified and analysed such as LNG, dual fuel, GTL fuel, Right sizing, CCNR II engines, Stage V engines, Hybrid propulsion with or without batteries, SCR, Wall flow, DPF, SCR and DPF, Fairway data, speed adaption and optimized track.

MARIGREEN

The MariGreen project[85], [86] (Maritime innovations in green technologies, 2015-2019) was focused on the development of innovations for greener and low-emission shipping that will ultimately reduce the ecological footprint of the shipping industry. This collaborative project between Germany and the Netherlands brought together shared goals to push international standards of excellence even further whilst promoting the profile of the region as a model in Green Shipping. The project concentrated specifically on small and medium enterprises in the transition towards a sustainable and viable shipping industry in accordance with the environmental and transport policy objectives of Germany, the Netherlands, and the EU.

Through a consortium of 59 German and Dutch maritime companies and research institutions, a total of 12 innovation projects were realized as part of the broader MariGreen Project. The technical objectives focused on LNG and wind-powered drive systems as well as green logistics alternatives – all with a focus on resource efficiency and safety in coastal and maritime transport. A key objective was also the cross-border recruitment of junior staff to the maritime industry and the creation of closer partnership opportunities between Germany and the Netherlands.

LeanShips

LeanShips was a European Innovation Project[87, 88](Horizon 2020 framework programme, 2015-2019) based on seven, mostly full-scale demonstrators on board ships. The project aimed to put innovations into practice by carrying out seven demonstrator show cases (Demo Cases) that combine technologies for efficient and less polluting vessels with end-users' needs and requirements.

Dedicated teams of equipment manufacturers (technology providers), shipyards (technology integrators), and ship owners (technology users) made certain that the innovations developed in the project were matured to market uptake capability. The ship types addressed by the project were small to midsized vessels for cargo and maritime operations, leisure, and inland shipping.

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[85] https://www.deutschland-nederland.eu/en/project/marigreen/

[86] http://en.marigreen.eu/

[87] https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/leanships

[88] https://www.leanships-project.eu/

E-ferry

E-ferry[89, 90] (2015-2020) addressed the urgent need for reducing European CO_2 emissions and air pollution from waterborne transportation by demonstrating the feasibility of a 100% electrically powered, emission free, medium sized ferry for passengers and cars, trucks, and cargo relevant to island communities, coastal zones, and inland waterways. The vessel was based on a newly developed, energy efficient design concept and demonstrated in full-scale operation on longer distances than previously seen for electric drive train ferries (> 5 Nm), i.e. the medium range connections Soeby-Fynshav (10.7 Nm) and Soeby-Faaborg (9.6 Nm) in the Danish part of the Baltic Sea, connecting the island of Aeroe (Ærø) to the mainland.

E-ferry had one of the largest battery-pack ever installed in a ferry with a record-breaking high charging power capacity of up to 4 MW allowing for short port stays. On top of being 100% powered by electricity, the innovative novelties of the E-ferry design concept and its expected impacts addresses flaws in current state-of-the-art by demonstrating a concept based on optimised hull-shape, lightweight equipment, and carbon composite materials, ensuring reduced weight by up to 60% on parts replaced by composite elements. Approval of the use of carbon fibre-reinforced composite modules in E-ferry's superstructure according to regulation through material and fire testing also was key to the project.

LNG Breakthrough

The objective of the CEF funded Action LNG Breakthrough[91] (2016-2019) was to reduce the investment barrier for ship owners with the aim of facilitating large scale implementation of LNG in inland navigation, thus forcing a breakthrough in the LNG market. This was done via:

- standardisation and type approval of the most common components and configurations (tank connection space, engines/engine rooms) resulting in an absolute reduction of the investment costs(estimated impact after project 20-30% reduction);
- application of innovative financial constructions in the business client relationship in order to avoid the need for capital investments by ship owners.

Through pilots (3 vessels) those standardised and type-approved configurations were validated and innovative business-client approaches were tested and validated. This Action contributed to unlock the roll-out to a potential market of 300 vessels. Moreover, attention was paid to business case calculations which were used to raise awareness and communicate the potential of LNG. In addition, a bunkering station for LNG was deployed in order to increase confidence that the required fuel infrastructure is available.

RIS-COMEX

Based on the outcome and key agreed concepts of the TEN-T study "RIS enabled European IWT Corridor management" (2012-EU-70004-S), the RIS COMEX project[92, 93] (2016-2021) will join the forces of 13 partner countries to improve cross-border cooperation with a view to achieving a service for the whole corridor, with common data quality, equal service level and unique access. The partnership encompasses the connected TEN-T core waterway network, from France over Belgium and Luxemburg

89 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/e-ferry
90 http://e-ferryproject.eu/
91 https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2014-nl-tm-0394-s
92 https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2015-eu-tm-0038-w
93 https://www.riscomex.eu/

to the Netherlands and via Germany to the Danube (with Austria, Slovak Republic, Hungary, Croatia, Republic of Bulgaria, Romania and also the non-Member State Serbia) and Czech Republic.

The RIS COMEX project aims for implementation and operation of cross-border River Information Services based on operational exchange of RIS data. These RIS-based Corridor (information) services shall allow for traffic management by the authorities and transport management by the logistics sector.

The project aims specifically at:

- Better planning of inland waterway transports (increased reliability of transport times)
- Reduction of waiting and travel times
- Increase of efficiency within the execution of inland navigation transports
- Optimal use of infrastructure (increased utilisation of capacities)
- Reduction of administrative barriers

ST4W

ST4W[94] (Smart Track for Waterway, 2017-2020) proposes a management solution for shipment by inland waterway transport, providing to small stakeholders a simpler and cheaper access to secure data, and enabling them to share a hierarchical track & trace service of shipment at logistics unit level: what pallet in what vessel?

ST4W solution will provide an end-to-end seamless visibility to supply chain stakeholders :

- Automatic update of logistics unit status (pallet, container …)
- Real-time update of ETA (Estimated Time of Arrival) of each logistics unit, throughout the multimodal supply chain
- Automatic alert in the case of delay or loading the wrong logistics unit
- Electronic proof of delivery at each step

This cloud-oriented platform is based on GS1 standards, where everyone is master of his own data and shares it only with chosen partners.

A sustainable and closer cooperation between waterway actors and their supply chain partners will enable more clients to make use of waterway transportation (from mental shift to modal shift), and consequently to reduce CO_2 emissions of their logistics operations.

NOVIMAR

NOVIMAR[95, 96] (2017-2021) aims to adjust inland/short-sea shipping such that it can make optimal use of the waterborne system of waterways, vessels, and ports/terminals. To achieve this, NOVIMAR introduces the waterborne version of 'platooning', the Vessel Train. This is in essence a number of unmanned Follower Ships with own sailing/manoeuvring capabilities being temporarily led by a manned Leader Ship. Vessels will be able to join and leave such trains at places adjacent to their points of origin and destination at seaside or inland. Envisaged main benefits and impacts are: Reduction of crew costs result in up to 47% total cost reduction for IWT and up to 88% crew cost reduction for short sea transport, Enhanced Logistic flexibility, 10-15 % less energy use/emissions. Solutions for overcoming barriers between transport modes and high potential for reducing road congestion and associated costs. Lower costs increase the attractiveness of small vessels at sea and inland, thereby increasing

[94] https://www.nweurope.eu/projects/project-search/st4w-smart-tracking-data-network-for-shipment-by-inland-waterway/

[95] https://cordis.europa.eu/project/id/723009

[96] https://novimar.eu/

access to urban areas located at small waterways (CEMT I/II), with no need for sizeable investments in infrastructures. SME's benefits include enhanced competitiveness and improved working conditions for vessel owners/operators, and market opportunities for equipment suppliers.

NOVIMAR technology developments include measuring, control and communication systems, and navigation aids for IWT use. NOVIMAR work structure contains 5 technical Work Packages dedicated to the Transport system, Impact assessment, Navigation, Cargo systems and vessels, and Safety and human skills issues.

GRENDEL

The GRENDEL project[97] (Green and efficient Danube Fleet, 2018-2020) supported the Danube vessel fleet operators and their public counterparts in modernisation of the sector. GRENDEL addressed various fleet modernisation aspects: i) use of low carbon & alternative fuels, ii) reduction of air pollutant emissions (CO_2, NO_x, PM) and iii) overall energy consumption. Besides this, iv) transport & logistics management processes were addressed to ensure better integration of the Danube IWT into logistics chains through new services (including River Information Services), digital data provision as well as dedicated tools to improve efficiency of fleet operations.

The project's overall goal is the improvement of the environmental and economic performance of the Danube fleet. This was achieved through three specific objectives:

- Know-how transfer for Danube fleet operators with the help of intensive transnational collaboration between private and public stakeholders and targeted know-how transfer activities in order to overcome the existing knowledge gap, lack of activities, and absence of instruments to deploy innovative solutions;
- Elaboration of innovative technical vessel concepts and improved transport & logistic management processes of fleet operators and sharing these as good practices for wide-scale implementation to strengthen the competitive position of inland navigation and to exploit its market potential;
- Supporting the development of a favourable regulatory framework & well-designed public support measures by introducing Model State Aid Scheme and innovative financial instruments to design national public support measures which clearly address the needs of the sector.

HyMethShip

The HyMethShip project[98, 99] (2018-2021) drastically reduces emissions and improves the efficiency of waterborne transport at the same time. This system will be developed, validated, and demonstrated on shore with a typical engine for marine applications in the range of 2 MW (TRL 6).

The HyMethShip system will achieve a reduction in CO_2 of more than 97% and will practically eliminate SOx and PM emissions. NOx emissions will be reduced by more than 80%, significantly below the IMO Tier III limit. The energy efficiency of the HyMethShip system is more than 45% better than the best available technology approach (renewable methanol as fuel coupled with conventional post-combustion carbon capturing).

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97 https://www.interreg-danube.eu/approved-projects/grendel

98 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hymethship

99 https://www.hymethship.com/

The HyMethShip system innovatively combines a membrane reactor, a CO2 capture system, a storage system for CO2 and methanol as well as a hydrogen-fuelled combustion engine into one system. The proposed solution reforms methanol to hydrogen, which is then burned in a conventional reciprocating engine that has been upgraded to burn multiple fuel types and specially optimized for hydrogen use.

SSAVE

SSAVE[100] stands for 'Shared Situational Awareness for Vessels' and is a VLAIO (Agentschap Innoveren & Ondernemen = Flanders Innovation & Entrepreneurship) funded project in Flanders, running from October 2019 until September 2021. The key objectives were to i) define methods and technologies for a safe connectivity and sharing of data, ii) defining low-cost IP-similar technologies for access to and sharing of data, iii) proposing standard formats for the exchange of sensor data, iv) standardising of inter-asset communication.

COMPETING

The ERASMUS+ funded COMPETING project[101] (2019-2021) will pave the way for the introduction of competency-based future-proof education and training for inland navigation crew members throughout the European Union. Future certificates will be recognised throughout Europe. Sustainable solutions, automation, and digitalisation as well as communication on a European level will be part of the education and training programmes. The ultimate goal of the project is to increase labour mobility in the inland shipping sector.

The development of a European-wide recognised and modern curriculum for IWT course manuals to implement competency-based education and training system as well as a Quality Assurance and Control system, resulting in a comparable and accompanying quality assurance and quality control system for recognition of educational programmes and properly qualified crew with the possession of a Union certificate.

AEGIS

The AEGIS[102] project (Advanced, Efficient and Green Intermodal Systems), 06/2020 – 05/2022, has dealt with Europe's next generation sustainable and highly competitive waterborne logistics system comprising more autonomous ships and automated cargo handling. Standardized cargo units and digital connectivity are key elements in the AEGIS system. AEGIS has also looked into three highly relevant use cases in Northern Europe, which however are applicable to other regions in Europe. The use cases represent typical short sea transports that need to be linked to last mile distribution systems.

100 https://www.blauwecluster.be/project/ssave-shared-situational-awareness-vessels
101 https://www.iwt-competencies.eu/
102 https://aegis.autonomous-ship.org/

Running Projects

CLINSH

The objective of LIFE CLINSH[103, 104] (Clean Inland Shipping, 2016-2022) is to improve air quality in urban areas situated close to ports and inland waterways, by accelerating IWT emission reductions. It will demonstrate the environmental impact of emission reduction technologies to facilitate the implementation and enforcement of EU policy and legislation on air quality, in particular the Clean Air Policy Package (2013) and the Air Quality Directive. Furthermore, nitrogen deposition (eutrophication) caused by ship emissions in Natura 2000 network sites close to waterways will be reduced for the benefit of biodiversity. The project will help facilitate a switch to lower emission levels in inland vessels, thereby helping to green the fleet with resulting health improvements in local populations.

CLINSH will provide insight into the effectiveness and cost benefits of emission-reduction measures under real-life conditions, and explore the available incentives for such measures (i.e. investment readiness). The project will demonstrate measures for emission reduction in selected vessels over two years. In tandem, the project team will undertake air quality modelling for different scenarios to show the impact on NO_x and PM10 concentrations, a methodology that will provide input for the further development of a Clean Shipping Index (CSI). The methodology will be disseminated to policymakers, ship owners and suppliers, and other decision-makers, and will help to improve the competitiveness of the inland navigation sector.

GASVESSEL

The GASVESSEL project[105, 106] (2017-2022) aims to prove the techno-economic feasibility of a new CNG transport concept enabled by a novel patented Pressure Vessel manufacturing technology and a new conceptual ship design including safe on- and offloading solutions. It carries out research and innovates different steps in the value chain from a decision support model to simulate and benchmark scenarios until the process of ship design, new Pressure Vessel designs and manufacturing as well as novel high pressure on- and offloading.

The project will make it possible to supply natural gas to places where natural gas is not yet a part of the energy supply, e.g. where large investment in regassifiers are not feasible or done (yet) such as the Mediterranean Islands. The concept offers novel cost-effective gas transportation and hence promising prospects to start using and monetising the huge amount of flared, stranded and associated gas which is currently wasted or not used, while contributing to reducing an important environmental side effect of global oil exploitation.

HySeas III

The HySeas III project[107, 108] (2018-2022) seeks to bring to market the world's first zero emission, seagoing ferry that will be powered by hydrogen from renewable sources. It builds upon the pioneering experience of the coordinator (Ferguson Marine), which previously developed the first diesel/electric

103 https://webgate.ec.europa.eu/life/publicWebsite/project/details/4505
104 https://www.clinsh.eu/
105 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/gasvessel
106 https://www.gasvessel.eu/
107 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hyseas-iii
108 https://www.hyseas3.eu/

hybrid ferry in 2013 and involves the leading European supplier of hydrogen fuel cell modules (Ballard Power Systems).

The project will not only develop and validate this advanced ferry concept, but a prototype version will be constructed and demonstrated in operational service with co-funding from the regional Government in Scotland (which will commission the building of the ferry). It will also demonstrate a novel circular economy model for the local production of hydrogen fuel that could transform the coastal and island economies around Europe.

DIWA

DIWA[109] (Masterplan Digitalisation of Inland Waterways, 2019-2022) is a CEF funded project aiming at developing a digitalisation strategy for IWT in the period 2022 until 2032. The project area covers altogether 5 European countries joined their forces under the coordination of the Dutch Waterway Administration Rijkswaterstaat with the common goal to realise a Digitalisation Masterplan.

The objective of the Action is to develop the Masterplan Digitalisation of Inland Waterways that will be a joint, uniform, and integral digitalisation strategy for IWT under the responsibility of the participating fairway authorities, ready for the execution in the period from 2022 until 2032. The Masterplan will consider the adaptation to the evolution of the policy and it will be based on (inter)national business developments related to the inland waterways traffic and transport domain, as well as on the game-changing technological developments of recent and coming years.

The Masterplan will consider the requirements put on this digital transition related to cybersecurity, standardisation, rules and regulations, security, and privacy. A digital information infrastructure requires also more and more attention for the quality of data and information. The Masterplan will focus in this context on procedures and processes for quality management during implementation and operation of the digital waterway infrastructure. It will include a set of implementation scenarios covering technical, organisational, financial, and operational consequences each Beneficiary will face in the digitalisation process.

STEERER

The EU-funded STEERER project[110, 111] (Structuring towards zero emission waterborne transport, 2019-2022) will advance and perform a communication strategy to raise awareness among both the waterborne transport industry and the citizens while engaging the sector to moderate climate change. The project will centre on a vast transition of both the existing fleet and the future generation of ships towards zero-emission by 2050 while taking into consideration the necessity of preparation of shipowners and operators for such a transition.

STEERER will coordinate the establishment and communication of a Strategic Research and Innovation Agenda (SRIA) and an Implementation Plan towards zero-emission waterborne transport, in cooperation with all key stakeholders needed to facilitate the transformation to clean waterborne transport. The project will develop and execute an effective communication strategy, to not only raise awareness to the key stakeholders of the waterborne transport sector as such, but by raising awareness of citizens regarding the strategic importance of the sector and the commitment of the sector to mitigate climate change and contribute to a healthy living environment. The consortium will function as a Secretariat,

109 https://www.masterplandiwa.eu/
110 https://cordis.europa.eu/project/id/875285
111 https://www.waterborne.eu/projects/coordination-projects/steerer/about-steerer

where the broader expertise is involved in the Scientific Committee and the Green Shipping Expert Group to be established by the project.

H2Ships

The Interreg North-West Europe project H2SHIPS project[112, 113] (2019-2022) will demonstrate the technical and economic feasibility of hydrogen bunkering and propulsion for shipping and will identify the conditions for successful market entry for the technology. Two pilot projects will be implemented as part of H2SHIPS: A new hydrogen powered port vessel will be built in Amsterdam, and a H2 refuelling system suitable for open sea operation will be developed and tested in Belgium. A further major output will be an action plan for the implementation of an H2SHIPS pilot on the river Seine in Paris in 2022. H2SHIPS will demonstrate the added-value of H2 for water transport and develop a blueprint for its adoption across North-West Europe, avoiding considerable GHG-emissions.

AutoShip

The Horizon 2020 Autoship project[114] (2019-2022) will build and operate two R&A vessels and their needed shore control and operation infrastructure, reaching and going over TRL7. Testing will take place during two pilot demonstration campaigns addressing goods mobility from the Baltic Corridor to a major EU seaport and hinterland, which are most relevant areas with growing waterborne transport market demand in EU. Doing so, it will speed-up the Next Generation of Autonomous Ships, by demonstrating in a real environment Short Sea Shipping and Inland Waterways autonomous vessels. The technology package will include fully autonomous navigation, self-diagnostic, prognostics and operation scheduling, as well as communication technology enabling a prominent level of cyber security and integrating the vessels into upgraded e-infrastructure. In parallel, digital tools and methodologies for design, simulation and cost analysis will be developed for the whole community of autonomous ships.

FLAGSHIPS

The FLAGSHIPS project[115, 116] (2019-2023) raises the readiness of zero-emission waterborne transport to an entirely new level by demonstrating two commercially operated hydrogen fuel cell vessels. The demo vessels include a newbuild in France (Lyon) and a retrofit in Norway (Stavanger) where the former is a push-boat operating as a utility vessel on one of the most demanding rivers, the Rhône, while the Stavanger demo is a passenger and car ferry operating as part of the local public transport network.

In the project, a total of 1.2 MW of onboard fuel cell power will be installed and both vessels will run on hydrogen produced on-site with electrolyzers powered by renewable electricity. Gaseous (Lyon) and liquid (Stavanger) hydrogen will be used in the vessels' on-board hydrogen storage. Both vessels will be approved for safety.

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112 https://www.nweurope.eu/projects/project-search/h2ships-system-based-solutions-for-h2-fuelled-water-transport-in-north-west-europe/
113 https://h2ships.org/
114 https://www.autoship-project.eu/
115 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/flagships
116 https://flagships.eu/

SeaTech

The SeaTech project[117, 118] (2020-2023) aims at developing two symbiotic ship engine and propulsion innovations that, when combined, could lead to a 30 percent reduction in fuel consumption. At the same time, the project envisions 99 percent reductions in emissions of sulphur oxides (SO_x) and nitrogen oxides (NO_x), a 46 percent reduction in CO_2 emissions, and a 94 percent reduction in particulate matter emissions.

The proposed engine power generation innovation is built around achieving ultra-high energy conversion efficiency. It involves precise controlling of the engine to achieve radical reductions in exhaust emission levels. The renewable energy-based propulsion innovation is a biomimetic dynamic wing mounted at the bow of the ship to augment propulsion in moderate and heavy sea conditions. By capturing wave energy, extra thrust is produced, and ship motions are dampened.

IW-NET

The vision of the EU-funded IW-NET project[119] (Innovation driven Collaborative European Inland Waterways Transport Network, 2020-2023) is to create an 'Innovation-driven Collaborative European Inland Waterways Transport Network' by following a holistic approach that not only covers digitalisation and multimodal integration in IWT but provides organisational and technological solutions for improved infrastructure management as well as for the next generation of green and innovative vessels.

IW-NET will deliver a multimodal optimisation process across the EU Transport System, increasing the modal share of IWT and supporting the EC’s ambitions to reduce transport GHG emissions by two thirds by 2050. Enablers for sustainable infrastructure management and innovative vessels will support an efficient and competitive IWT sector addressing infrastructure bottlenecks, insufficient IT integration along the chain and slow adoption of technologies such as new vessel types, alternative fuels, automation, IoT, machine learning. The Living Lab will apply user-centered application scenarios in important TEN-T corridors demonstrating and evaluating the impacts in simulations and tests covering technological, organisational, legal, economical, ecological, and safety/security issues:

- **Digitalisation**: optimised planning of barge operations serving dense urban areas with predictive demand routing (Brussels-Antwerp-Courtrai-Lille-Valenciennes); data driven optimisation on navigability in uncertain water conditions (Danube).
- **Sustainable Infrastructure and Intelligent Traffic Management**: lock forecasting reducing uncertainty in voyage planning; lock planning; management of fairway sections where encounters are prohibited; berth planning with mandatory shore power supply and other services (hinterland of Bremerhaven via Weser/Mittelland Canal).
- **Innovative vessels**: new barge designs fitting corridor conditions and target markets: barges with a high degree of automation for urban distribution (East Flanders-Ghent); new barge for push boats capable with low/high water levels optimising capacities (Danube from Austria to Romania); use of GALILEO services for advanced driver assistance like guidance, bridge height warning and automatic lock entering (Spree-Oder waterway close to Berlin).

117 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/seatech
118 https://seatech2020.eu/
119 https://cordis.europa.eu/project/id/861377

RH2INE

Rhine Hydrogen Integration Network of Excellence (RH_2INE), endorsed by the Dutch Ministry of Infrastructure and Water Management, is an initiative of the Province of Zuid-Holland and the Ministry of Economic Affairs, Innovation, Digitisation and Energy of North Rhine-Westphalia.

RH2INE[120] (2020-2023) is the first comprehensive corridor approach to one of the key priorities of CEF, i.e. “enabling and strengthening the synergies between energy, transport and telecom”. Focussing on the EU’s ambition to become the first zero emission continent, RH2INE seeks to realise market-ready hydrogen applications along one of EU’s oldest core network corridors, powered by the first sustainable and interoperable gas and electricity networks in the world.

NAUTILUS

The NAUTILUS project[121, 122] (2020-2024) aims at developing, evaluating, and validating a highly efficient power generation system fuelled by Liquefied Natural Gas (LNG) for long-haul passenger ships. The to-be-developed system will cut greenhouse gas (GHG) emissions by 50% and all other diesel engine exhaust gas emission components almost entirely.

The NAUTILUS project will develop a complete concept of a fully integrated energy system between 5 and 60 MW for a 1000 passenger expedition cruise vessel and a 5000+ passenger cruise ship. Additionally, a 60 kW functional demonstrator of the SOFC-battery will be developed, engineered, assembled and operated to validate the design and operation strategies. The digital design, as well as the physical demonstrator, will be evaluated against marine safety regulations.

FASTWATER

The EU-funded FASTWATER project[123, 124] (2020-2024) aims to reduce its greenhouse and pollutant emissions by using methanol fuel. Methanol is a clean fuel, available in large quantities in most ports, and can easily be stored on board. FASTWATER elaborates an evolutionary pathway for methanol, including retrofit solutions. The project will develop retrofit kits and methanol engines and demonstrate these in a harbour tugboat, a pilot boat, and a coast guard vessel. A methanol powered river cruise vessel design is also included, as well as logistics and bunkering, revision of rules and regulations, and crew training. Eventually, FASTWATER will implement business plans including the life cycle performance analysis of costs, CO_2 and pollutant reductions, to commercialise the solutions developed.

FASTWATER focuses on methanol, a clean fuel, available in large quantities in most ports today and offering a pathway to a climate-neutral synthetic fuel produced from renewables. Methanol is suited for internal combustion engines (ICE), gas turbines as well as fuel cells. As a liquid fuel, it is easily stored on board, which is advantageous to ship design, and enables relatively simple retrofitting. Consequently, the EU’s Joint Research Centre’s study on alternative fuels for shipping states that methanol is one of the most promising options to decarbonise the shipping sector. FASTWATER aims to start a fast transitionary path to move waterborne transport away from fossil fuels, and reduce its pollutant emissions to zero impact, through the use of methanol fuel.

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[120] https://www.rh2ine.eu/

[121] https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/nautilus

[122] https://nautilus-project.eu/

[123] https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/fastwater

[124] https://www.fastwater.eu/

NOVIMOVE

The ability of ports to ensure efficient cargo transfers is central to their overall function and an important factor that influences port terminal attractiveness. The EU-funded NOVIMOVE project[125, 126] (Novel inland waterway transport concepts for moving freight effectively, 2020-2024) will conduct research on how to improve the logistics of this transport system. The project will reduce waiting times at seaports by improving river voyage planning and execution and facilitating smooth passages through bridges and locks. Focussing on the Rhine–Alpine water corridor from Rotterdam/Antwerp all the way to Basel, it will validate its new technology with virtual simulations, scaled model tests and full-scale demonstrations.

Inland Waterway Transport (IWT) advantages as low-energy and low CO_2 emitting transport mode are not fully exploited today due to gaps in the logistics system. Inland container vessels pay 6-8 calls at seaport terminals with long waiting times. More time is lost by sub-optimal navigation on rivers and waiting at bridges and locks. In addition, low load factors of containers and vessels impact the logistics systems with unnecessarily high numbers of containers being transported and trips being made. NOVIMOVE strategy is to “condense” the logistics system by improving container load factors and by reducing waiting times in seaports, by improved river voyage planning and execution, and by facilitating smooth passages through bridges and locks.

NOVIMOVE’s innovations are: (1) cargo reconstruction to raise container load factors, (2) mobile terminals feeding inland barges, (3) smart river navigation by merging satellite (Galileo) and real time river water depths data, (4) smooth passage through bridges/locks by dynamic scheduling systems for better corridor management along the TEN-T Rhine-Alpine (R-A) route, (5) concepts for innovative vessels that can adapt to low water conditions while maintaining a full payload, and (6) close cooperation with logistic stakeholders, ports and water authorities along the R-A route: Antwerp, Rotterdam, Duisburg, Basel.

ShipFC

The EU-funded ShipFC project[127], [128] (2020-2025) will install the world’s first ammonia-powered fuel cell on a vessel. The project will see an offshore vessel retrofitted with a large, 2-megawatt, ammonia fuel cell[129], which allows it to sail solely on the clean fuel for up to 3 000 hours annually. As such, the project will demonstrate that long-range zero-emission voyages with high power on larger ships is possible.

ShipFC’s main mission is to prove and show the case for large-scale zero-emission shipping. It does this through developing, piloting, and replicating a modular 2MW fuel cell technology using ammonia as fuel. The project will first adapt and scale-up existing fuel cell solutions to a 2MW system, develop ship and land fuel systems for ammonia and integrate the full system onboard a large offshore construction vessel. Then the solution will be validated through commercial operation for at least 3000 hours during a one-year period. Moreover, socio-technical models and analysis will be performed and a full feasibility study on a series of additional vessels will be conducted.

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125 https://cordis.europa.eu/project/id/858508

126 https://novimove.eu/2020/

127 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/shipfc

128 https://shipfc.eu/

129 Ammonia is considered dangerous and unworkable for safety reasons in inland navigation by both the CCNR and its Member States. For more information, please see the AVIV-report on “Safety aspects of new energy sources inland navigation” which can be downloaded here: https://puc.overheid.nl/rijkswaterstaat/doc/PUC_710445_31/.

Note: The technologies considered reflect the current state of knowledge. In the CCNR Roadmap for emissions reduction[130], it was decided to focus on a set of technologies with a technology readiness level (TRL) of 5 and above. Some were not considered mature enough to be used, especially in light of current cost predictions. However, no technologies should be excluded at this juncture. For instance, other technological options like lithium-air batteries, LOHC (Liquid Organic Hydrogen Carrier), formic acid (hydrozine) or green ammonia in combination with fuel cells (FC) or internal combustion engines (ICE) might play roles in later stages of the energy transition. Regarding ammonia, for instance, it is a serious candidate as an energy carrier for seagoing vessels but still presents important safety issues to be investigated in inland navigation. Eventually, some other technologies which are not known today might be deployed in the next decades.

Current Direct

Current Direct[131, 132] (2021-2023) is a research and innovation project funded by the European Commission's Horizon 2020 program that will revolutionize the way we move goods and people by water with the use of swappable containerized batteries connected to an Energy as a Service (EaaS) Platform.

Current Direct addresses EU challenges by developing and demonstrating an innovative, interchangeable waterborne transport battery system and an Energy as a Service (EaaS) Platform in an operational environment in the Port of Rotterdam. Current Direct will consider its integration across the range of different vessel types used in the coastal and inland waterway transport industry, including short to medium range freight and ferry services. The system being developed will allow Current Direct to reach the following objectives:

- Significantly reduce the total lifetime cost of waterborne transport batteries by 50% through novel materials, manufacturing processes and optimized components.
- Cut GHG emissions of the marine transport sector through electrification of existing and future vessel fleets.
- Increase the installed energy of containerized energy storage systems by 300% compared to currently available systems.
- Trigger investments for innovation, employment, and knowledge creation in the European marine transport and battery energy storage sectors.

SEABAT

The European SEABAT project[133, 134] (2021-2024) applies a modular approach, with the aim to reduce component costs (battery, convertor) so that unique ship designs can profit from economies of scale by using standardised low-cost modular components. In SEABAT existing commercial battery cells will be used, the concept will be suitable for future battery generations and high-power components that may have higher power densities or are based on different chemistries. The concept is based on:

- combining modular high-energy batteries and high-power batteries,
- novel converter concepts and

[130] CCNR, "Roadmap for reducing inland navigation emissions", March 2022, https://www.ccr-zkr.org/files/documents/Roadmap/Roadmap_en.pdf.

[131] https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/current-direct

[132] https://www.currentdirect.eu/

[133] https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/seabat

[134] https://seabat-h2020.eu/

- production technology solutions derived from the automotive sector.

SEABAT takes the challenge to substantially reduce the costs of large waterborne transport battery systems by developing a full-electric maritime hybrid concept that combines high-energy and high-power storage cells.

e-SHyIPS

The e-SHyIPS project[135, 136] (2021-2024) aims to define the new guidelines for an effective introduction of hydrogen in maritime passenger transport sector and to boost its adoption within the global and EU strategy for a clean and sustainable environment, towards the accomplishment of a zero-emission navigation scenario.

Through an ecosystem approach, where all the main stakeholders from maritime and hydrogen sectors, research and industry will be involved, the e-SHyIPS project will integrate theoretical pre-normative research activities on standards with simulation and laboratory experiments, in order to provide the needed knowledge to design an appropriate certification process and spot future standardization activities to enhance the EU's normative and regulatory landscape.

The goal of the e-SHyIPS project is to move from the idea to the application, such as to fill the existing gap in normative and technical knowledge concerning all the related aspects on hydrogen in the maritime transport sector.

ENGIMMONIA

ENGIMMONIA[137, 138] (2021-2025) studies the benefits of using a carbon-free fuel like ammonia[139] (that in any case could have a GHG impact due to N_2O emissions that should be properly treated by an EATS to be developed in ENGIMMONIA under AUTH/DTU supervision) in vessel engines also coupling its benefits/performances with other clean energy technologies like:

- waste heat recovery solutions based on ORC and adsorption chiller for the production of electricity and space cooling respectively,
- renewables integration on board thanks to the installation of PV composite surface easily installable on vessel structural parts ,
- on board fuel/energy/heat management optimization via real time Energy Management System; towards the creation of ENGIMMONIA polygeneration energy hub.

HyShip

The HyShip project[140, 141] (2021-2025) focuses on the design and construction of a new ro-ro demonstration vessel running on liquid green hydrogen (LH2), as well as the establishment of a viable LH2 supply chain and bunkering platform. The ship will be operated by Norwegian maritime industry group Wilhelmsen and will distribute LH2 to hydrogen hubs along the Norwegian coast. It is slated to be operational from 2024.

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135 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/e-shyips
136 https://e-shyips.com/
137 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/engimmonia
138 https://www.engimmonia.eu/
139 For use of ammonia in IWT, please see footnote 129
140 https://www.waterborne.eu/projects/energy-efficiency-and-zero-emissions/hyship
141 https://hyship.eu/

Going under the concept name "Topeka", the vessel will be the first of its kind to enter commercial service. Providing a two-in-one solution (1,000 kWh battery capacity and a three-megawatt proton exchange membrane hydrogen fuel cell), it will sail on a fixed schedule carrying both coastwise customer cargo and containerized LH2 to the bunkering hubs. Norway's west coast is dotted with bases serving the offshore industries, with base-to-base transport representing a heavy-duty transport route eminently suited to LH2. HyShip will be a large-scale validation of both the ship, its innovative power system, and the distribution network. The bunkering hubs will in the future supply LH2-powered vessels including ferries and seagoing tonnage.

CAMPFIRE

Within CAMPFIRE (CF), project line CF08 aims to equip inland waterway vessels with an ammonia-fuelled ICE and to install the necessary tank, safety and peripheral systems. The ammonia-based propulsion system will supply the test vessel with the energy required for a regular service without emissions. On the basis of the functional model, the feasibility and functionality of the ammonia-based drive system and the fuel handling will be investigated. In this way, ground-breaking research and development work will be carried out regarding the technological requirements for the modification of inland vessels of the existing fleet with new ammonia propulsion systems as well as their operation. Together with the concurrent worked-out results of an economic feasibility study and the approach within existing safety and legal frameworks, the project results will also serve as a blueprint for the adaptation of inland vessels. In CF08_1 a concept for an ammonia-powered inland waterway vessel will be developed as a functional model for a selected ferry line in preparation for the conversion of the vessel. Furthermore, a 70 kW ammonia reformer is developed and implemented as a key technology for the engine operation of the ferry. A fundamental basis for a retrofitting of inland waterway vessels will be derived from it.

ZULU ASSOCIATES

ZULU Associates is active as initiator, developer and operator of innovations in the marine component of logistic chains. Its goal is to enable zero emission operation of commercial vessels on inland waterways, short sea and coastal routes through automated operation and alternative propulsion. ZULU Associates was established to regroup and exploit innovations in logistic chains with a marine content. The marine industry, whether seagoing or inland, is fiercely traditional and faces huge challenges and opportunities regarding emissions, alternative propulsion, digital revolution, automated operation and its role in logistic chains. ZULU Associates believes that these opportunities will result in disruptive innovations which will change radically the way a number of marine services will operate and this in a relative short period. By actively pursuing these innovations and creating the elements for their success, ZULU Associates is convinced important long-term value can be created for its stakeholders.

Smarte Holzlogistik (Smart logistics of wood)

Within the Austrian PhysICAL project[142] (Physical Internet through Cooperative Austrian Logistics), four pilots are under investigation one of which is "Smarte Holzlogistik" (smart logistics of wood). The pilot develops standardised and intelligent loading units for wood transport (both logs and wood products) are equipped with GPS and weighing systems to optimally load the units in the forests already. The commonly used loading units reduce the amount of crane operations, truck rides, and waiting times and it is expected to reduce 30% of road transport volumes by moving them to rail.

[142] https://physical-project.at/

Annex B: Working groups, platforms, further studies

The following list of working groups, platforms, further studies and projects comprises further initiatives and projects beyond what was summarised in chapter 3 of this deliverable. For each of the entries, its title, a short description, the duration, and the link to work packages of PLATINA3 are provided.

Expert, Working Groups, Committees

- EC Expert Groups for IWT: There are currently different Expert Groups chaired by DG MOVE Unit D.3 “Ports & Inland Navigation”. These are the groups on DINA (Digital Inland Navigation Area) including RIS “River Information Services”, “NAIADES II implementation”, “Social Issues”.
- CESNI: The European committee for drawing up standards in the field of inland navigation (CESNI) is an innovative governing body at European level which develops uniform, modern, user-friendly requirements for inland navigation regarding vessels, crew and IT. Duration: 2015 – ongoing. The committee is a joint instrument of CCNR and EU and its purpose is to bring together experts from the Member States of the EU and the CCNR and representatives of international organisations with an interest in inland navigation.
- DTLF (Digital Transport and Logistics Forum)[143]: The DTLF is a EC expert group that brings together stakeholders from different transport and logistics communities, from both the private and the public sector, with a view to build a common vision and road map for digital transport and logistics. Its task is to assist the Commission in developing and implementing policy measures. It identifies challenges and areas where common action in the EU is needed, provides recommendations, and supports the implementation of these recommendations where appropriate.
- Good Navigation Status (GNS): Study[144] and expert group on the elaboration of the Good Navigation Status concept in the TEN-T Guidelines and recommendations for the revision of legislation. Duration 2017-2020.
- DINA[145]: Further to the European DINA study of 2017, the DINA Expert Group of the EC deals with all digital developments from navigation and traffic management, integration in logistics processes and administrative formalities including costs involved in complying with and enforcing legislation.
- PIANC working groups 22, 178, 2010, PTGCC: WG 22 “Development of guidelines for sustainable performance indicators for inland waterways.” WG 178 ”Climate Change Adaptation Planning for Ports and Inland Waterways “, WG 210 “Smart Shipping on Inland Waterways”, “PTGCC: Permanent Task Group on Climate Change”.

Platforms

- ETP-ALICE[146]: Technology platform for zero-emission and integrated logistics through physical internet. Duration: ongoing

143 https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?do=groupDetail.groupDetail&groupID=3280

144 https://op.europa.eu/en/publication-detail/-/publication/7980f36c-3eca-11e8-b5fe-01aa75ed71a1

145 https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vkin9vxe8iyv

146 https://www.etp-logistics.eu/

- Technology Platform WATERBORNE[147]: The industry-oriented Technology Platform to establish a continuous dialogue between all waterborne stakeholders, to develop a common medium- and long-term R&D Vision, a Technical Research Agenda and Strategic Research Agenda. WaterborneTP is also coordinating the Co-Programmed Partnership on Zero-Emission Waterborne Transport (ZEWT cPP) in the framework of Horizon Europe (HEU), which will provide and demonstrate zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050. Duration 2005 -ongoing.
- EIBIP[148]: European platform of regional innovation facilitation centres in Germany, France, Danube and The Netherlands (Innovation Lab), to promote the uptake of innovation by the IWT sector (funded by EC DG MOVE until 2019). Duration: 2016-ongoing.

Other studies

- Study on the energy transition towards a zero-emission IWT149 (Duration 2019-2021) : Study funded by CCNR on the energy transition for a zero emission European inland navigation sector focusing on technical and financial aspects. It aimed at:
    - analysing the possible financial instruments for inland navigation including the availability of grants on national level (Member State contributions) and EU programmes.
    - Researching the existing polluter-pays schemes and whether they could be applicable to the IWT market as well as assessing the corresponding market impacts and legal aspects. This exercise contributed to preparing the decision making on the setting-up of a European scheme for the greening/ transition of the fleet, looking at funding opportunities by the sector,
    - Performing a technical and economic assessment of the technologies already available or expected to become available for the transition of the IWT sector towards a zero-emission

Further projects

- ENTRANCE[150, 151] (European matchmaking platform for innovative transport and mobility tools and services, 2021-2023) provides a European matchmaking platform and complementary off-line services, designed to mobilise financial resources to accelerate the market access and scale-up of pioneering sustainable transport solutions. The project will identify innovative zero-emission transport solutions and promote their registration on the ENTRANCE platform where they can be matched with potential buyers and financing opportunities. Knowledge on good practices on the deployment of innovative solutions, European and national tenders and legislation, will be exchanged through the online platform. Training and brokerage activities will take place and ENTRANCE will facilitate purchase aggregation by setting up a neutral trustee for the orchestration of collaborations. Access to finance will be supported through individual and personalised innovation finance advice and support.
- FENIX[152] (A European Federated Network of Information eXchange in LogistiX, 2019-2022): The overall aim is to support the development, validation and deployment of digital information

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147 https://www.waterborne.eu/
148 https://eibip.eu/
149 https://www.ccr-zkr.org/12080000-en.html
150 https://cordis.europa.eu/project/id/101006681
151 https://www.entrance-platform.eu/
152 https://fenix-network.eu/

systems along the EU transport Core Network and notably corridors. The focus is on the implementation of "corridor information systems" according to the specific EU objective to build a federated network of information exchange platforms, involving both public authorities and business stakeholders. The compelling enablers to address these demands are technology innovations such as: Internet of Things (IoT), Big Data, Data Integration, Data Analytics, Data Products, Intelligent Transportation Systems (ITS) and new satellite navigation technologies; linked to new business models by creating opportunities to conceive, form and deploy new corridor management systems. It builds further on the project AEOLIX which was finished in 2019. Multimodal planners linked to execution control have been recognised as key enablers of future logistics operations.

- FEDeRATED[153] (Developing the foundations for a secure, open and neutral data sharing infrastructure provision through practical Living Labs, 2019-2023): an EU Member States driven initiative to contribute to the establishment of a viable federated network of platforms for data sharing in the freight transport and logistics domain at EU level (and beyond). The main objective is to enable a smooth and effective public involvement with logistic chains for the execution of public duties. The FEDeRATED projects builds upon the work and recommendation of the Digital Transport and Logistic Forum (DTLF), and in particular its subgroup 2, to create such viable and valid federative network of platforms as an enabler for Business to Administration (B2A), Administration to Business (A2B), and Business to Business (B2B) data exchange and sharing.
- SELiiS[154, 155] (Towards a Shared European Logistics Intelligent Information Space, 2016-2019): SELIS aimed at delivering a ‘platform for pan-European logistics applications’. It embraces a wide spectrum of logistics perspectives and creating a unifying operational and strategic business innovation agenda for pan European Green Logistics. It established a consortium of logistics stakeholders and ICT providers. It established a research and innovation environment using the living labs to provide data than can be used for discovery of new insights that will enable continuous value creation supporting the large scale adoption of SELIS. The Shared European Logistics Intelligent Information Space is a network of logistic communities’ specific shared intelligent information spaces termed SELIS Community Nodes. The SELIS Community Node concept represents the evolution of a longline of research in this area. The fundamental principle is that it provides a ‘lightweight ICT structure’ to enable information sharing for collaborative sustainable logistics for all at strategic and operational levels.
- LEARN[156](Logistics Emission Accounting and Reduction Network, 2016-2019) / GLEC[157] (Global Logistics Emission Council): methodology to measure and improve CO_2 emissions in logistics, including IWT, demonstrated in the LEARN-project. GLEC has an active group of freight forwarding companies.
- INTERGO research on the human factor in accidents: Research of available statistical data, to identify and prioritise the main causes of selected categories of accidents in inland navigation and in-depth analysis through gathering of practical experience.

153 http://www.federatedplatforms.eu/
154 https://cordis.europa.eu/project/id/690588
155 http://www.selisproject.eu/
156 https://learnproject.net/
157 https://www.smartfreightcentre.org/en/how-to-implement-items/what-is-glec-framework/58/

Annex C: Innovative ideas

Loading units and transhipment infrastructure

UNIT45.COM

Description: UNIT45[158] is market leader in the development and construction of 45 ft containers. They claim that the 45 ft container concept represents the most efficient solution for the logistical modality problems of the future and is fully compatible with European legislation. They also adapt the dimensions, equipment, materials, access sides, and functionality to the needs of the clients. Due to its standard dimensions, one container can optimally handle 33 euro-pallets.

CargoBeamer

Description: The German CargoBeamer[159] concept proposes a fast and sustainable solution for semi-trailers in the modal shift from road to rail. Using this concept, all sorts of semi-trailers can be loaded and unloaded automatically from trucks to a 700 m long train within 20 minutes. Since most of the semi-trailers cannot (easily) be transferred via cranes, CargoBeamer uses a horizontal loading and unloading technology. The system is adaptable to all types of semi-trailers and uses standard track profiles according to the TSI (Technical Specifications for Interoperability) specification. There are currently five terminals in operation across Europe (UK, France, Germany, and Italy).

Danubia-Kombi

Description: Danubia-Kombi[160] has been developed in Austria and is an intermodal transport system for the Danube. The patented technology is using so-called FLATS which are standard-sized loading units on which the goods are placed. The system can transport all kinds of goods and transport units currently transported by road such as swap bodies, inland containers, transport vehicles, trailers (incl. those not suitable for crane handling or stacking), loose goods (installations, machine parts, new car vehicles, loose freight), and ISO containers. The FLATS are then stacked on the ships in up to four layers using adapted crane facilities. Ships need to be equipped or retro-fitted with the DANUBIA shelf-system to allow for stacking the units. The concept promises increased loading capacity, a reduction of costs, and a decrease in environmental impacts.

Smart mobility concepts

CoVadem

Description: CoVadem[161] is a smart solution for real-time collection of ship and river data. CoVadem states that modern IWT vessels can gain more than €25k/year by optimising cargo volume and fairway condition-optimised operation, with huge environmental benefits as a bonus. This requires improved information and interrelated metrics where CoVadem, as a 'Software as a Service' (SaaS) based service, adds value to inland vessels by smartly enabling optimisation of cargo revenue and reduction of risk, energy costs & climate impact. No investment is required, as it works on a subscription basis.

CoVadem collects, analyses, combines and distributes vessel-sourced measurements to provide a fairway covering information service with best available real time and forecast information on available depths.

158 https://unit45.com/en/
159 https://www.cargobeamer.de
160 http://danubia-kombi.com/
161 https://www.covadem.com/en/home

Measuring vessels are equipped with a small and secure data collection device, the CoVadem Box, paid by CoVadem. Measuring vessels own their data, vessel specific data are not shared with any 3rd parties and are treated anonymously.

Needs:

- Upscaling of the measuring network to at least 250 vessels;
- Further development of services, further calibration and validation of data;
- Development and introduction of automated bENC[162] production and ECDIS[163] integration.

SEAFAR

Description: SEAFAR[164, 165] is a crew-reduced vessel monitored and operated by a shore skipper on small waterways in Belgium. The idea is to increase operational efficiency, to maximise cargo space, reduce operating expenses and energy cost, increase safety and decrease risk of accidents, solve crew shortage in the inland shipping sector, and make inland navigation an attractive profession for young people and the digital generation.

Needs:

- Exemptions for remote-controlled and automated inland shipping on more European waterways in close cooperation with international and national authorities (e.g. CCNR is working on an exemption for Seafar for cross-border navigation on the international Rhine);
- Regulation, research, education and training for skippers in shore control centres;
- Allow skippers to operate inland vessels from a shore control centre

SWINg - Single Window for Inland Navigation

Description: SWINg[166, 167] is an innovative registration platform in Flanders, Belgium, which is operative from 2021 and which requires shippers and inland waterway companies to register ship, travel, and good details only once within Flanders and the Wester Schelde. Previously, this registration (with similar or the same details) was necessary whenever vessels enter into a different authority region. The digitalisation improvement use existing digital systems to connect to the registration platform SWINg and therefore does not require installation of new soft- or hardware on board of the vessels.

Needs:

- The platform needs to be made active (URL does not work yet);
- No further needs known.

Watertruck+

Description: Watertruck+[168, 169] is an innovative concept for freight transport that opens up a region by means of small barges (self-propelled or non-propelled) on small waterways and transports the

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162 bENC = bathymetric electronic navigational charts
163 ECDIS = Electronic Chart Display and Information System
164 https://seafar.eu/
165 Flyer 'SEAFAR', Green Inland Shipping Event, Brussels, 16 October 2019, available via Inland Navigation Europe, https://www.inlandnavigation.eu/
166 http://www.swing-platform.be/
167 https://www.apzi.be/nieuws/innovatie-in-de-binnenvaart-met-digitaal-platform-swing (in Dutch)
168 https://www.vlaamsewaterweg.be/watertruck
169 https://youtu.be/75St6sC0qTI

cargo in convoy via larger waterways. The short-term goal of the Watertruck+ project is the construction of a fleet of 30 barges and two pusher boats that will be used during pilot projects and the preparation of a master plan for scaling up and using the water truck concept in Europe. The concept allows for shifting more goods from other transport modes to inland waterways and also plans to save about 25% of CO_2 as compared to any existing system by using alternative fuel types and new propulsion systems. Some final remarks and thoughts after the final event of Watertruck+ in February 2021 are summarised in a YouTube video under https://www.youtube.com/watch?v=h6xBhiCnd88.

Needs:
- private investors for the small barges;
- design of a masterplan for the project.

Others

Further projects dealing with smart mobility concepts include:
- SciPPPer[170] (Schleusenassistenzsystem basierend auf PPP und VDES für die Binnenschifffahrt), 2018-2021;
- FernBin[171] (Bausteine zum ferngesteuerten Fahren von Binnenschiffen), 2020-2023;
- SELECT[172] (Smarte Entscheidungsassistenz für Logistikketten der Binnenschifffahrt durch ETA-Prognosen), 2020-2023;
- EFTIbarge[173] (Einbindung der Binnenschifffahrt in den modernen digitalen Datenaustausch), 2021-2022;
- Verbundprojekt DigitalSOW[174] - Digitales Testfeld für automatisierte und autonome Binnenschifffahrt auf der Spree-Oder-Wasserstraße (SOW), 06/2021-06/2023.

New fuel technologies

ECOTanker

Description: The 110m x 11.4m tanker vessel ECOTANKER III[175] uses a gas-electric powertrain with Liquefied Natural Gas (LNG), reducing CO_2 by approximately 40%, NO_x by 80-90%, and PM to zero. LNG is odourless, non-corrosive and non-toxic and requires less storage volume if cooled down to -162°C. The use of LNG typically reduces noise (due to the use of electric engines) and fuel costs.

Needs:
- Funding opportunities
- New financial instruments
- Modular LNG fuel tank systems

170 http://scippper.de/ (in German)
171 https://www.binsmart.de/forschungsvorhaben/bausteine-zum-ferngesteuerten-fahren-von-binnen-schiffen/
172 https://www.logistik.tu-berlin.de/menue/forschung/aktuelle_forschungsprojekte/select/parameter/en/
173 https://www.binsmart.de/forschungsvorhaben/eftibarge-einbindung-der-binnenschifffahrt-in-den-modernen-digitalen-datenaustausch/
174 https://www.digitalsow.de/de/digitalsow.html
175 Flyer 'ECOTANKER', Green Inland Shipping Event, Brussels, 16 October 2019, available via Inland Navigation Europe, https://www.inlandnavigation.eu/

HYDROVILLE

Description: Hydroville is a 14m x 4.2m, 16 passenger shuttle featuring a dual fuel hydrogen diesel co-combustion engine with pressurized hydrogen. It operates at a cruise speed of 20/22 kn and reaches emission reductions in the range of 58% to 73% for CO_2, 57% for PM, and 65% for NO_x. It serves as a sailing laboratory to test new hydrogen technologies, to raise awareness and inform, to service as a shuttle for CMB staff to avoid traffic jams.

Needs:

- Develop dual fuel (hydrogen – diesel) combustion engines which reach displacements of up to 85% H_2
- Mono fuel hydrogen engine with NO_x <0.2gr/kWh without the need for after treatment

EMELI

Description: EMELI is a 55m x 7.2m cargo vessel with a retrofit diesel-electric powertrain used for training purposes. It uses hydrogen and allows for 10 hours full power zero emission propulsion. Due to its electric engines the emission reduction (when sailing on hydrogen) is 100% for CO_2, PM, and NO_x.

Needs:

- Rules and regulations
- Supply chain and infrastructure
- Business case
- Affordable green hydrogen
- R&D to reduce costs of fuel cells and to increase durability
- R&D to optimise hydrogen storage on board and the effective hydrogen carriers
- Financing and funding solutions

SENDOLINER

Description: SendoLiner[176, 177] is a 110m x 11.5m container vessel operated by a battery/diesel-electric power train. It is the first commercial freight vessel to sail zero emission on charged battery (up to 3h) with a modular platform allowing to change to different techniques. It reduces CO_2 emissions by 40%, PM by 45%, and NO_x by 45%. SendoLiner is a fully electrified vessel (propulsion and bowthrusters), it is optimized for most common operating condition such as shallow water of just 1.5m below the keel and an operating speed of 14 km/h by means of Computational Fluid Dynamics.

Needs:

- High power charging facilities on shore;
- Funding and financing for the development of containerised exchangeable power boxes, for multi purpose applications (also net stabilisation, off-grid power for construction yards and festivals) including recharging and transhipment locations along waterways;
- Funding and financing for retrofitting existing vessels with electric propulsion and bow thrusters

[176] https://sendo-shipping.nl/

[177] Flyer 'SendoLiner', Green Inland Shipping Event, Brussels, 16 October 2019, available via Inland Navigation Europe, https://www.inlandnavigation.eu/

Others

Further projects dealing with new fuel technologies comprise:

- ELEKTRA II[178] (Realisierung und Erprobung eines Schubbootes als Versuchsträger eines Brennstoffzellen und Akkumulatoren hybridbetriebenen Antriebssystems für den Einsatz auf Binnenwasserstraßen)

Retrofit and technical solutions

EuroVI engines

Description: The use of Euro VI, stage 5 truck engines for IWT has been demonstrated via the 86m x 9m vessel 'Wantij'[179] which has received a new diesel engine, including a Diesel Particulate Filter (DPF) and a Selective Catalytic Reduction (SCR) unit in 2018 leading to a reduction of CO (94%), PM (97%), NO_x (95%), and HC (98%).

Needs:

- Integration of IWT in the Renewable Energy Directive and further incentives for biofuels and synthetic fuels;
- Funding and financing solutions to provide a business case for retrofitting existing vessels;
- Funding for R&D projects for development of hybrid solutions and modular applications

FlaBi

Description: The German research project FlaBi[180] (Entwicklung von Binnenschiffen für extreme Niedrigwasserbedingungen), 2021-2023, deals with the development of new or retrofitted vessels to match the extreme climate conditions (draughts) recently observed at the Rhine and Elbe waterways.

Urban transport solutions

FLUDIS

Description: Fludis[181] is a 38-meter-long electrically powered warehouse ship, operating in the Seine basin, and equipped with two on-board cranes to put pallets ashore and capable of accommodating up to 30 electric-powered CYCLOFRET® cargo bicycles. Therefore, no port handling infrastructure is required. For four stops in Paris, each bike can ensure up to 4 tours per day, each carrying up to 250 kg of parcels. A single ship, fully equipped, therefore avoids in one year 300,000 kilometers of delivery by road around Paris which is equivalent to the emission of 110 tonnes of CO_2.

CYCLOFRET® is an intermodal cargo bike for the transport of goods over «the last mile» or in the warehouse. It has the capacity to transport pallets or containers in Euro-pallet format, for a total payload of 250 kg and a usable volume of 1.7 m³. It is self-unloading and does not need any handling tools to load or unload pallets or containers.

178 https://www.behala.de/elektra/

179 Flyer 'Wantij', Green Inland Shipping Event, Brussels, 16 October 2019, available via Inland Navigation Europe, https://www.inlandnavigation.eu/

180 https://www.dst-org.de/verbundvorhaben-flabi-gestartet/ (in German)

181 https://fludis.eu/?lang=en

Needs:

- River decision-makers support this innovative solution for urban logistics
- Approval from waterway authorities for the transport of goods
- A home port to load Fludis + waterside stops along the delivery journey
- Customers with high volumes of parcels (suppliers, shipping companies, forwarders, shippers)

ROBOAT

Description: Roboat[182] is a 5-year-long research project and collaboration between the Amsterdam Institute for Advanced Metropolitan Solutions and the Massachusetts Institute of Technology. In developing the world's first fleet of autonomous floating vessels for the city of Amsterdam, it investigates the potential of self-driving technology to change our cities and their waterways. Mapping, localization, object detection, path planning and path following using a combination of advanced sensors such as LiDAR, stereoscopic camera's, IMU and GPS. Four static thrusters allow for precise manoeuvring, including lateral movements to enable the Roboat to latch to each other and create a scalable platform. The vessel is fully electric and can operate up to 9 hours. Potential use cases are passenger transport, freight transport, garbage transport, and on-demand infrastructure.

Needs:

- Laws/regulations concerning autonomous sailing on urban waterways
- Additional funding to speed-up development and pilots
- Execution of real-life pilots in Amsterdam, eg picking up private waste in old town Amsterdam (pilot is scheduled for 2021)
- Uptake of technology by private company, eg waste collection company

A_SWARM

Description: A_SWARM[183] (2019-2022) is a research project in Germany to develop technologies for an autonomous operation of electrically propelled vessels on inland waterways. The focus of this project is on autonomous movements of the vessel on water, the necessary sensors, and potential infrastructure along the inland waterways. The final use of this technology is foreseen for urban areas. Demonstration is planned in the lab and on inland waterways in Berlin, Germany.

Needs:

- Further development of infrastructure, remote access, loading and unloading
- Investors for demonstration and propotype vessels
- Regulations on waterways for autonomous vessels

AutoBin

Description: The research project AutoBin[184, 185] (2019-2022), supported by EU funding, aims to develop and test an autonomously driving inland waterway vessel. The test vessel is a typical inland waterway vessel (100m x 10.5m). The project develops a control system which allows to manoeuvre a

182 https://roboat.org/
183 https://www.sva-potsdam.de/category/forschung/ (in German)
184 https://www.binsmart.de/forschungsvorhaben/autonomes-binnenschiff-simulation-und-demonstration-von-automatisiertem-fahren-in-der-binnenschifffahrt/ (in German)
185 https://www.autobin.de/ (in German)

vessel from a starting point to an end point without human intervention, collision avoidance (embankments, structures, other vessels) and respecting all traffic control measures.

Needs:
- Retrofitting of existing inland waterway vessels
- Regulations on waterways for autonomous vessels

AVATAR

Description: AVATAR[186] (2020-2023) stands for 'Autonomous vessels, cost-effective transhipment, waste return' and is a POM East Flanders supported project to deploy zero-emission automated vessels that can do hourly traffic between the Urban Consolidation Centers outside the city and inner-city hubs, focusing on the distribution of palletized goods and waste return. The AVATAR project aims to tackle challenges of city freight distribution by developing, testing and assessing adequate technologies and business models for urban autonomous zero-emission IWT. Through this, the project unlocks the economic potential of urban vessels and corresponding waterways, increases available solutions for full-cycle automation and sets up a sustainable supply chain model for urban goods distribution and waste return.

Others

Further projects dealing with Urban transport solutions are e.g.
- ZAWAS[187] (Zero-emission Automated WAter Shuttles)
- DigitalSOW[188] (Digitales Testfeld für automatisierte und autonome Binnenschifffahrt auf der Spree-Oder-Wasserstraße), 2021-2023
- CAPTN Förde Areal[189] (Erprobung einer (teil-)autonomen, emissionsfreien Fährschifffahrt im digitalen Testfeld), 2021-2023
- HANNAH[190] (High Autonomous Navigation with Nautic Artificial Horizon), 2021-2022

186 https://northsearegion.eu/avatar/
187 https://maritimecleantech.no/project/zawas/
188 https://www.digitalsow.de/digitalsow.html (in German)
189 https://captn.sh/foerde-areal/ (in German)
190 https://www.binsmart.de/forschungsvorhaben/hannah-high-autonomous-navigation-with-nautic-artificial-horizon/ (in German)

Annex D: Further publications

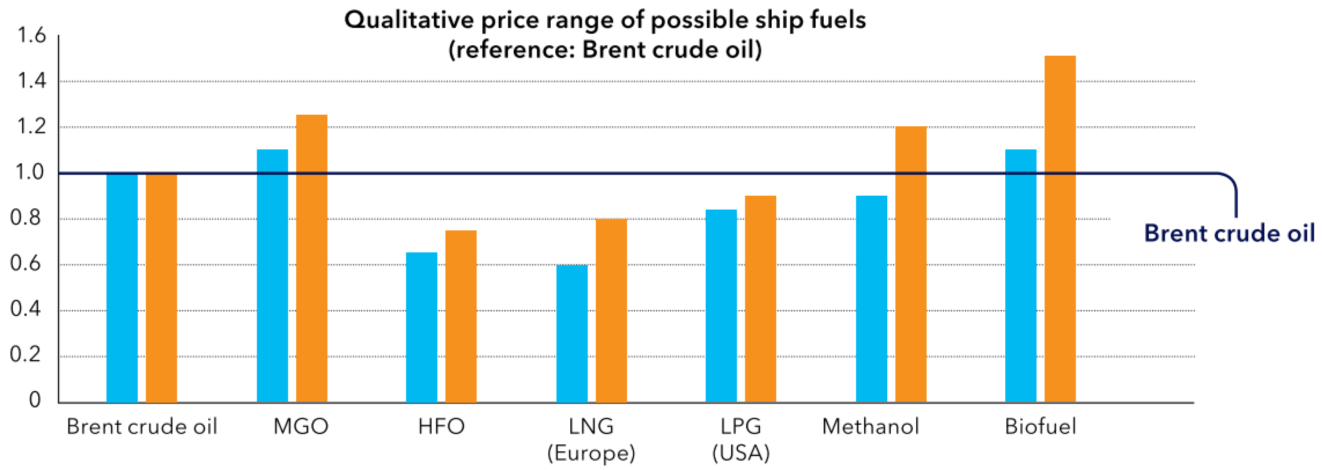
Alternative fuels

EIBIP et al. (2017)[20] have discussed various alternative fuels (LNG/CNG, GTL, Biofuels, Methanol, Ethanol, and Hydrogen), incl. their characteristics, potential barriers and measures and potential action takers to overcome those barriers. LNG/CNG and hybrid (diesel/electric) solutions were proposed for inland waterway vessels, depending on the yearly consumptions of those vessels. It also becomes clear from the report that the technical possibility alone will not solve the issue but needs to be supported by industry, ship owners, fuel suppliers, cargo owners, authorities (on all levels), equipment suppliers, and banks. This will require an overall mind shift from various stakeholder groups but has been identified as a promising concept.

In 2019, DNV GL - Maritime has produced a guidance report on alternative fuels and technologies[191] which was mainly aiming for the maritime shipping sector but specific parts could potentially be transferred to IWT. The report provides guidance on the background of the fuel production (LNG, LPG, Methanol, Biofuels, Hydrogen, Power To Fuel, Wind, Batteries, Fuel Cells), discusses the overall emission behaviour, compares fuel prices (see Figure 9) and fuel availability (Figure 10), and provides the following conclusions:

- The decision of the International Maritime Organization (IMO) to limit the sulphur content of ship fuels from 1 January 2020 to 0.5 per cent worldwide, and the recently adopted ambition to reduce GHG emission by 50 per cent by 2050 have the potential to become game changers.
- There is an accelerating worldwide trend towards lower emissions of CO_2, NO_X, and particles.
- DNV GL identified LNG, LPG, methanol, biofuel and hydrogen as the most promising alternative fuels for shipping.
- DNV GL believes battery systems, fuel cell systems and wind-assisted propulsion have reasonable potential for ship applications.
- As has been demonstrated by the DNV GL PERFECt Ship concept study, the well-known combined cycle gas and steam turbine technology has good potential for ships in the power range above 30 MW, provided that low-sulphur fuels are widely used in shipping.
- The major challenges for alternative fuels are related to environmental benefits, fuel availability in the quantities needed for shipping, fuel costs and the international rules within the IGF Code.
- Of all fossil fuels, LNG produces the lowest CO_2 emissions. However, it will not be sufficient in view of the IMO vision to de-carbonizing shipping.
- In a sustainable energy world where all energy is produced by renewable CO_2-neutral sources, hydrogen and CO_2 will be the basis for fuel production.

[191] DNV GL (2019). Assessment of selected alternative fuels and technologies, DNV GL, 56 pp.



	Brent crude oil	MGO	HFO	LNG (Europe)	LPG (USA)	Methanol	Biofuel
Min.	1	1.1	0.65	0.6	0.85	0.9	1.1
Max.	1	1.25	0.75	0.8	0.9	1.2	1.5

Source: DNV GL, IEA

Figure 9. Comparison of alternative fuel prices (Source: DNV GL, 2019[191])

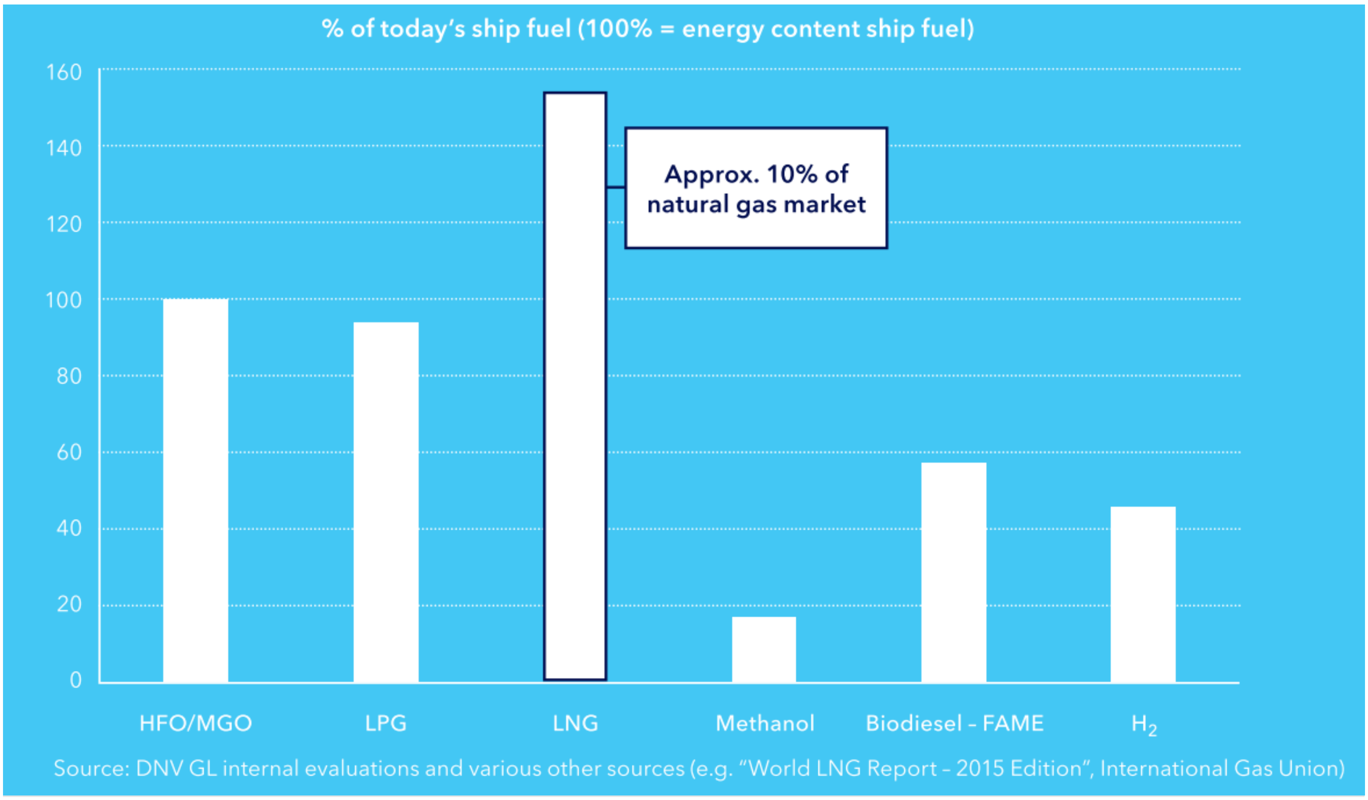


Figure 10. Availability of alternative fuels (Source: DNV GL, 2019[191])

- All propulsion concepts are capable of meeting the emission limits using any of the fuel alternatives.
- For international shipping, it should be noted that subsidies financed by taxes on fuel for preferred fuels do not exist because there is no taxation on ship fuels.

EFIP and other sector organisations[192] in 2021 comment on the updated alternative fuel regulation by the European Commission (AFIR). The organisations criticise that the current wording does not tackle all the relevant and upcoming challenges such as the on-shore power supply (OPS) and the corridor (TEN-T) frameworks (rather than National Policy Frameworks). The paper also suggests amendments to the proposed legislative text document.

In 2019[193] and 2020[194], Verberght performed an extensive analysis on innovation in inland waterways, where, among others,- -a detailed analysis (innovation analysis, cost-benefit analysis, and a so-called Pan-European Inland Navigation Policy analysis) of an LNG-diesel dual fuel inland vessel was performed. Conclusions can be summarised as follows:

- the removal of the regulatory bottleneck for LNG as described by the literature was a main failure factor for the implementation of the proposed solution next to the lack of bunkering infrastructure;
- the results from the economic analysis are not convincing to invest in LNG engines without subsidies for the considered vessel;
- the cash flow analysis considers external costs and showed that LNG as a fuel has a significant benefit in reducing emissions but is not convincing in reducing greenhouse gases.

In accordance with the mandate given by the Mannheim Ministerial Declaration of 17 October 2018[19], the CCNR adopted a roadmap (2021)[20] aimed at largely eliminating GHG emissions and air pollutants in the IWT sector by 2050, a long-term vision also shared by the EU. Built upon the CCNR study on the energy transition towards a zero-emissions inland navigation sector (hereafter "CCNR study")[21], this roadmap shall be understood as the primary CCNR instrument for mitigating climate change, fostering the energy transition, and contributing to the European IWT policy. As this energy transition represents a crucial challenge to Rhine and European inland navigation, the aim of the roadmap is to contribute to a reduction in emissions from Rhine and inland waterways navigation by:

- setting transition pathways for the fleet (new and existing vessels),
- suggesting, planning, and implementing measures directly adopted or not by the CCNR,
- monitoring the intermediate and final objectives laid down by the Mannheim Declaration.

192 EFIP, EBU, INE, ESO and IWT Platform (2021). Position of the European Federation of Inland Ports (EFIP), Inland Navigation Europe (INE) and the Inland Waterway Transport sector on the Alternative Fuels Infrastructure Regulation (AFIR). European Federation of Inland Ports (EFIP), European Barge Union (EBU), Inland Navigation Europe (INE), European Skippers Organisation (ESO) and European IWT Platform (IWT): 2 pp.

193 Verberght, E. (2019). Innovative Inland Navigation (INN-IN), University of Antwerp, Faculty of Applied Economics, Department of Transport and Regional Economics (TPR), 298 pp.

194 Verberght, E. (2020). Innovation in Inland Navigation: Failure and Success. The European case. PhD thesis. University of Antwerp, Belgium, Department of Transport and Regional Economics, Faculty of Business and Economics, 239 pp.

Retrofit and technical solutions

The first ever LNG retrofit vessel was reported by De Leijer et al. (2015), see footnote 24, for a barge by the Danser Group who installed a dual-fuel system (LNG / gasoil) allowing for a LNG powered propulsion by 99%.

Other fuel, energy, and time saving solution for inland waterways comprise (see e.g. also the MOVE-IT project in Annex A):

- Magnetic mooring pads
- New power system configurations
- Improved hull and propulsors;
- Assistance to the captain for efficient sailing

EIBIP et al. (2017)[20] have discussed energy efficient technical solutions for greening the fleet such as energy-efficient navigation, energy efficient ship designs, hybrid/diesel-electric propulsion, and electric propulsion. Also measures to reduce emissions such as air pollutant emission reduction, alternative technologies, and new engine concepts or optimisations as well as after-treatment measures were reviewed. For all solutions, the state-of-the-art is briefly discussed, the barriers are listed, and potential measures and instruments to overcome these barriers are provided.

Verberght (2020)[194] has performed a detailed analysis of an automated and unmanned inland vessel where a computer (system) takes over the operations which were previously performed by a human being. It principally shows that such automation is technically possible, and it is only a matter of time for partially automated, unmanned vessels to enter the market.

Annex E: Resolution 2021/2015(INI): modal shift

Modal shift in freight: from road to inland waterways

1. Calls on the Commission to take the initiative on green, efficient and digital leadership and to build on existing programmes such as NAIADES, which should support and incentivise all stakeholders within the waterway transport sector, as well as other transport modes, in particular rail, to work together towards a sustainable and social future, while supporting entrepreneurship, the protection of workers and the competitiveness of the sector as a whole;
    - emphasises that inland waterways constitute an excellent transport mode for commodities originating from new circular economy markets and that coordinating transport, environmental and industrial policies is key to seizing these opportunities;

2. Calls on the Commission and the Member States to take better account of the fact that those operating in the inland waterway sector are often families with children on board and to invest in adequate and regular facilities along waterway routes in order to provide decent living conditions en route;

3. Calls on the Commission to present proposals for a governance and regulatory framework in line with the next NAIADES action programme, ensuring harmonisation and standardisation at EU level for quality navigability, vessels and crew qualifications;
    - points out that this framework should facilitate the coordination of investments, action programmes and the various bodies involved in inland waterway transport development, including the Member States' administrations, EU agencies, TEN-T coordinators, river commissions and standardisation committees;
    - **highlights the opportunity to map a potential modal shift in the transport of goods to inland waterways through the NAIADES III action programme**;
    - **highlights that this modal shift and better coordination between industrial and transport policies would help to achieve the objectives of the Green Deal**, requiring almost all industrial sectors to undergo a sustainable and circular transformation;

4. Welcomes the Commission's intention expressed in the Sustainable and Smart Mobility Strategy to shift more goods from road to inland waterways and short-sea shipping, including regional, urban and intercity freight transport;
    - stresses, nevertheless, the considerable untapped potential and scope for expansion of inland waterway transport;
    - calls on the Commission, therefore, **to regularly evaluate and step up its ambitions for the modal shift goals of inland waterway transport** and to reap the benefits of the sector;
    - calls on the Commission, furthermore, to support the uptake of best practices on **integrating inland waterway transport services into multimodal logistics chains**;
    - stresses that **investments are needed in more flexible and innovative ship designs** and in greening the existing inland waterway transport fleet, **developing inter alia river-adapted ships and other mature, sustainable solutions to provide a more competitive and sustainable alternative to road transport**;

5. Stresses that more and regular investment in expanding, updating and upgrading the physical and digital infrastructure of inland waterways, such as locks, bridges and the interoperable deployment of digital technologies across borders, is key to boosting the competitiveness of the sector, to preventing its decline, to improving its long-term performance, reliability and predictability across borders, **to enabling quality navigability and to facilitating the modal shift**, while respecting biodiversity concerns and the applicable environmental law such as the Water Framework Directive(11) and the Nature Directives(12);

- calls on the Commission to facilitate the exchange of best practices across Member States, with particular regard to taking account of fauna and flora needs in infrastructure projects;

6. Urges the Member States to fully respect their obligation to complete the TEN-T core inland waterway network by 2030 and calls on the Commission and the TEN-T coordinators to strengthen oversight in this regard;
   - calls on the Member States to eliminate the missing links, tackle bottlenecks and promote quality physical and digital infrastructure;
   - highlights, in particular, the need to **increase investments in adequate multimodal infrastructure in ports and hinterland connections of inland ports, such as seamless rail connections and terminals, and to increase their storage capacity in order to facilitate competitive multimodal transport in Europe** and enhance their supply chain performance;

7. Deems it necessary to introduce a dual-layer network approach by complementing the existing core network of inland waterways with a comprehensive network of inland waterways in order to bolster inland waterway transport;
   - points out that navigable waterways which are connected to sea ports and do not have class IV status but have the potential to reduce negative environmental externalities, including road congestion, should be considered for the comprehensive network;
   - stresses the need, therefore, to extend the TEN-T network to incorporate new inland waterway sections into core and comprehensive networks in order **to establish new multimodal transport hubs**;

8. Considers it important to recognise the untapped potential of smaller waterways to enhance direct competition with road transport, by ensuring a detailed, comprehensive and intricate network that is kept up-to-date and navigable;
   - calls on the Commission to not only consider large waterways, but to include smaller waterways in the digital transition;

9. Underlines the significant potential in refurbishing connecting waterways and canals, especially in regions that have suffered from decades of insufficient investment in inland waterway infrastructure;

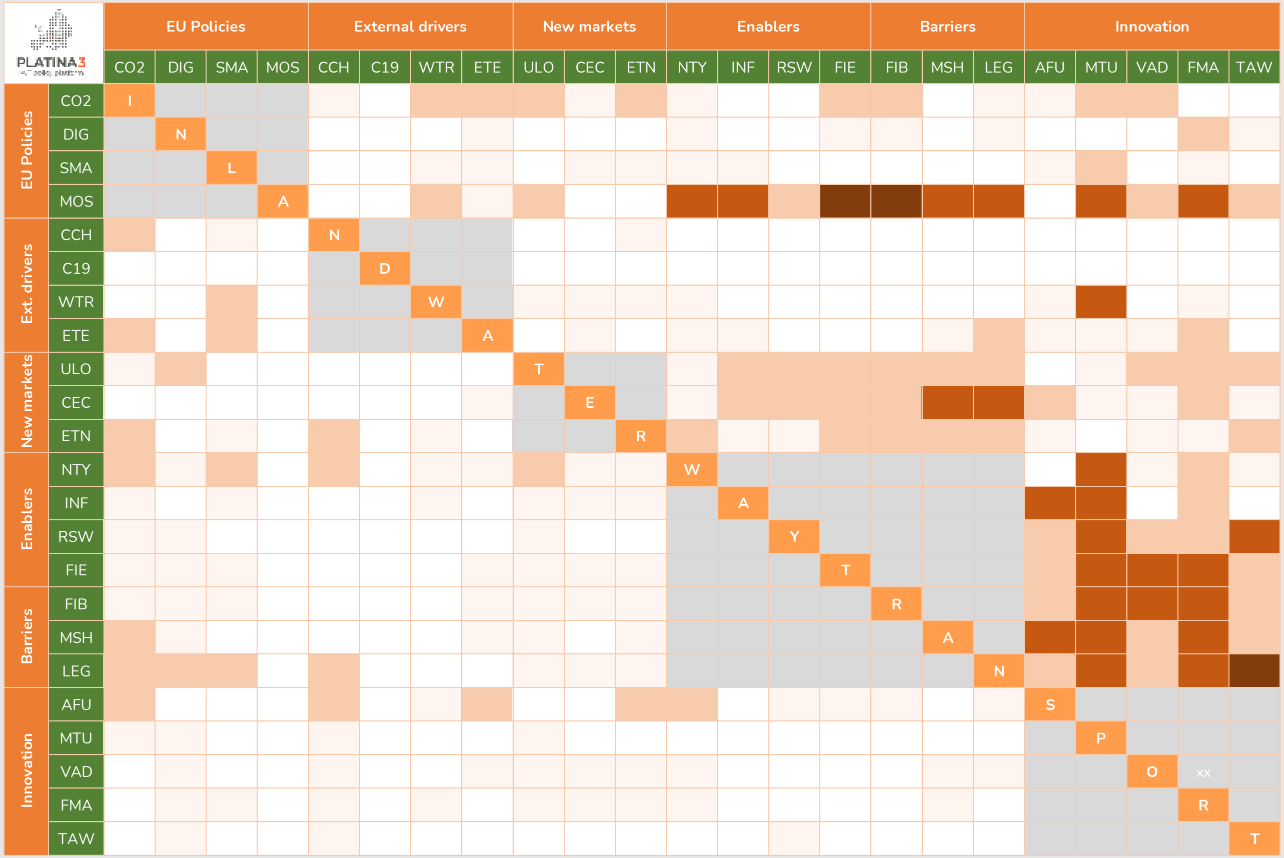
10. Calls on the Member States to ensure that all the relevant stakeholders are engaged in the multidisciplinary planning process for new navigation projects and maintenance measures in order to devise commonly accepted solutions in line with EU legislation;

11. Notes that waterway transport needs a more effective, reliable, safe and climate-resilient infrastructure network to better tackle the problem of flooding and low water levels, which will only get worse due to the effects of climate change;
   - deplores the fact that the problems affecting the inland waterway sector caused by flooding and low water levels have not been taken duly into account and that ensuring navigability is key;
   - stresses the need, therefore, to take coherent action, such as adapting fleets, including the type of ships, quantity of fleet and spare capacity, optimising ship design, taking account of the versatility of inland waterway vessels, ensuring the better management and development of infrastructure, providing more accurate information about water levels and forecasting, cooperating with rail during low water periods, drawing up time charter contracts for vessels which are able to operate during low water tide periods, implementing digital tools, and increasing storage capacity in ports;
   - calls on the Commission and the Member States to draw up action plans to combat low water levels and stresses the need for coordination to this end;

12. Stresses the importance of using space data and services for inland waterway transport services to ensure a safer, more sustainable, efficient and competitive sector;

- considers, in particular, that new services in the Galileo and Copernicus programmes and the European Geostationary Navigation Overlay Service (EGNOS) should be included in the review of the ITS Directive(13) and other smart mobility legislative initiatives;

Annex F: Gap Identification Matrix



CO2	=	Decarbonisation
DIG	=	Digitalisation
SMA	=	Single Market
MOS	=	Modal shift
CCH	=	Climate change
C19	=	COVID-19
WTR	=	World trade
ETE	=	Energy transition
ULO	=	Urban logistics
CEC	=	Circular economy
ETN	=	Energy transition
NTY	=	New technology
INF	=	Infrastructure
RSW	=	Re-skilling workforce
FIE	=	Financing
FIB	=	Financing
MSH	=	Mind shift
LEG	=	Legislation
AFU	=	Alternative fuels
MTU	=	Modal trade units
VAD	=	Vessel adaptation
FMA	=	Freight management
TAW	=	Training & awareness

		from	to
(darkest)	=	80	100
	=	60	80
	=	40	60
	=	20	40
(lightest)	=	0	20

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