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Study on Enabling Sustainable Management and Development of inland ports

D2.1 Good Practices in urban mobility and short-range IWT

Essen, 16 May 2024

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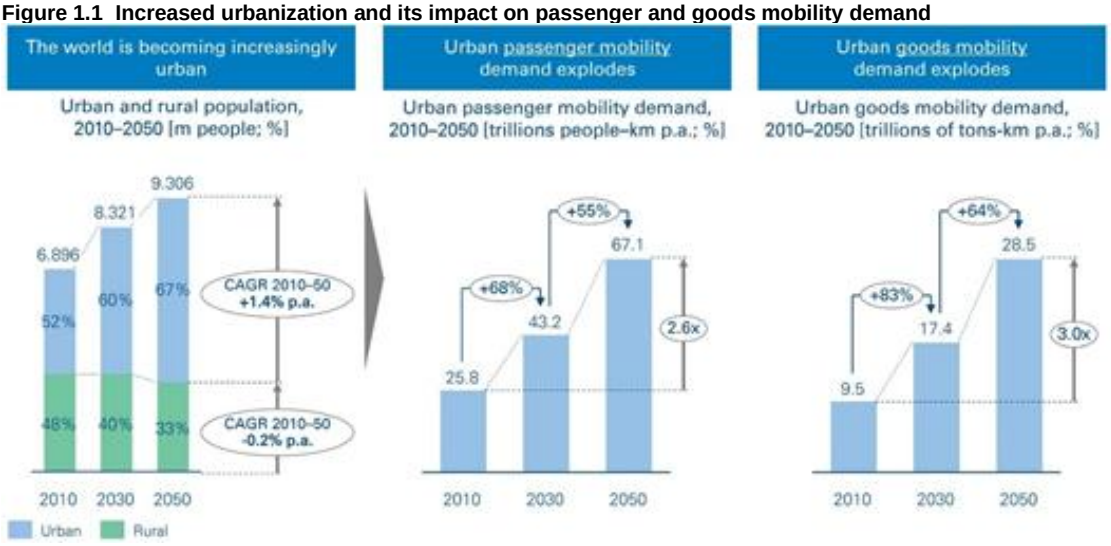
1 Introduction

1.1 Urban and short-range IWT as part of sustainable inland port management

This Deliverable 2.1 reports about tasks 2.1 and 2.2 of the Green Inland Ports study on good practices for urban and short-range IWT. As part of the sustainable management and development of inland ports the adoption of inland waterway transport beyond traditional purposes in urban environments and over short distances is analysed.

There is a strong need to find sustainable solutions for urban mobility of passengers and freight, considering the expected growth of these segments in the coming years, as presented in Figure 1.1. The increasing urbanisation will further increase the transport volumes in cities.

Figure 1.1 Increased urbanization and its impact on passenger and goods mobility demand



Source: UN, World Bank, OECD, ITF, Schäfer/Victor 2000, Cosgrove/Cargett 2007, Arthur D. Little

Smart concepts and business models are needed for the establishment of new markets for urban and short-range inland waterway transport. Analysing the traditional inland waterways transport structures, there is a large potential for the development of these market segments, also considering the opportunity of unmanned (small) vessels to serve these areas. However, due to the handling in ports, business cases and competition with other modes are challenging for short-range IWT. The growing need for resource efficient transport and congestion of (urban) road networks and protection of inner cities with cultural heritage lead to an increasing potential in this market segment. This applies for freight transport, where for instance increasing parcel deliveries from distribution centres moving to the outskirts of cities increase truck transport. This also applies to passenger transport, where waterborne concepts can contribute to modal shift from road to public transport as well as reduce emissions through the use of electric vessels. Moreover, it includes last mile operation in the hinterland of ports where efficient solutions can strengthen the sustainability. The use of urban and short-range IWT will allow to reduce urban congestion which is estimated to create an economic loss EUR 180 billion per year.[1]

Various creative solutions exist already, and this analysis will contribute to their development and further maturing to contribute to a transfer of short-range IWT solutions to other locations. The results

[1] See European Commission, Smart and Sustainable Mobility Strategy, Staff Working Document, 2020.

of the analysis, highlighting valuable insights, will allow to fully exploit the potential of inland navigation for the modal shift of road transport. A further exploitation of the potential of urban and short-range IWT is in line with the European Green Deal objectives to shift 75% of inland freight transport from road to rail and inland waterways.[2] Moreover, considering economic change and the breakaway of traditional markets for inland navigation, these new markets are crucial to avoid a cutback of IWT market shares and with this a lower contribution of inland ports to sustainability.

Now is a good moment to implement new services. After the COVID crisis, the attitude of the population in urban areas is changing. A survey in Brussels learned that silence was the most appreciated effect of the crisis. Silence caused by fewer cars, fewer trucks and less air transport. Closely followed by the second positive effect of less cars and trucks, which created more safety and space for pedestrians and bikers. The better air quality was the third very well appreciated effect.

Consequently, there is a common understanding that traffic problems in urban areas cannot be solved only by implementation of alternative fuels. Consequently, it can be expected that changes in rules and regulations will support a modal shift and (hopefully) pave the way for green urban logistics and mobility solutions.

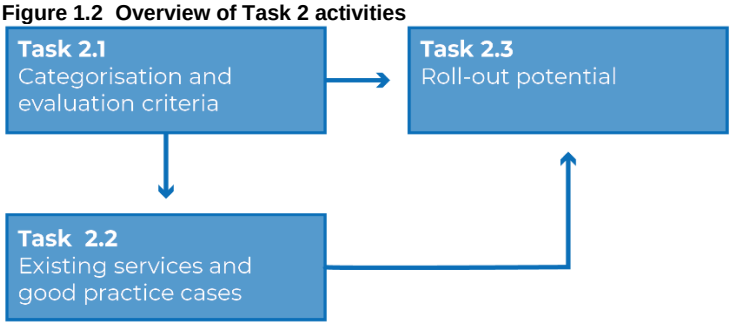
1.2 Task 2 methodology and approach

The objective of task 2 is to contribute to the adoption of inland waterway transport beyond its traditional markets. It is aimed for the development of urban mobility and short-range IWT markets to exploit its potential for the sustainable management and development of inland ports. The identification of existing initiatives over Europe and the analysis of challenges and success factors aims for a promising fundament for the strengthening of urban mobility and short-range IWT in European inland ports.

To deliver this objective the following sub-tasks are carried out:
Sub-tasks 2.1: Categorisation and evaluation criteria
Sub-tasks 2.2: Existing services and good practice cases
Sub-tasks 2.3: Roll-out potential

Figure 1.2 represents the relationship between the sub-tasks of Task 2.

Figure 1.2 Overview of Task 2 activities



Source: Consortium

[2] See https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

It is the idea to identify good practices in urban mobility and short range IWT and learn from them to strengthen IWT in these markets. 20 good practices are identified to show smart concepts and business models as well as lessons learnt which can be used to draw recommendations how to develop feasible services and overcome existing barriers. Moreover, good practices can show how to support the set-up of new services by inland ports and other stakeholders. A careful selection of good practices is implemented to have a solid base for the recommendations and pave the way for a roll-out of solutions beyond existing services.

Task 2.1 serves the fundament for the selection of good practices by providing the categorisation and the evaluation framework. The categorisation will facilitate the analysis of services by market segment considering their specifics. The joint analysis allows to better identify solutions to overcome existing barriers and untap potential. Moreover, the categorisation contributes to a balanced coverage of market segments and regions. A balanced coverage for the selection of the 20 good practice cases allows for a wide scope of recommendations.

Task 2.2 is in the core of the analysis. It gives an overview of existing urban mobility and short-range IWT services divided by category and delivers a detailed analysis of 20 good practice cases. Existing services and some key characteristics were gathered by literature research and a survey among inland port representatives and stakeholders. Good practice cases are selected based on a quick-scan-analysis. Those good practice cases are subject of an in-depth analysis covering relevant service components. Evaluation criteria are applied to analyse case studies in a harmonised way including interviews with involved stakeholders. A standardised evaluation framework is developed to present the good practice cases and the in-depth evaluation. Based on evaluations recommendations are drafted regarding the development of services.

Task 2.3 concludes the analysis by addressing the potential for urban and short-range IWT beyond existing services. Based on the evaluation of good practice cases their roll-out potential is analysed. Moreover, the potential beyond the cases will be roughly estimated.

1.3 Content of Deliverable 2.1

This Deliverable 2.1 Good Practices in urban mobility and short-range IWT will present the findings and conclusions of tasks 2.1 and 2.2. A separate Deliverable 2.2 Potential for urban mobility and short-range IWT will be prepared for Task 2.3.

Following to the introduction chapter 2 outlines the development of approach and methodology for analysing urban and short-range IWT services including categorisation scheme, quick scan analysis for selection of good practice cases and the in-depth evaluation of cases. First, the categorisation scheme covering various categories for the structuring of urban and short-range of services is illustrated. Then, the quick-scan analysis including relevant determinants is briefly described.

The analysis of key service characteristics and challenges for the development of urban and short-range IWT services is the basis for the design of evaluation criteria in the next step. The rationale for the developed criteria and relevant components are outlined. Building on this, the approach for evaluation and the applied evaluation scale and template for presentation of good practice cases are introduced. This completes the analysis framework as result of task 2.1.

Chapter 3.2 reports about the identification of urban and short-range services through the Green Inland Ports study survey and additional desk research. The identified services will be categorised according to the developed scheme and listed by market segment. The selection of 20 good practice cases and underlying key success factors are presented in chapter 3.3.

The analysis of the selected good practice cases is outlined by market segment. For each service, a profile based on the standardised template including introduction, evaluation criteria and conclusions is available.

Lessons learnt from the analysis of the good practice cases regarding the development of urban and short-range IWT services are presented in chapter 4. As a result, key factors for the successful development of this market segment are presented.

2 Task 2.1: Categorisation and evaluation criteria

2.1 Categorisation

2.1.1 Approach

The categorisation aims to distinguish services in urban mobility and short range IWT. The following market segments will be analysed:

- Urban passenger transport
- Urban freight transport
- Short range freight transport

Urban freight transport is understood as transport in metropolitan areas, means cities including surrounding areas especially with warehouse or industry locations. Short range freight transport is understood as transport over distances shorter than normally seen as economically feasible distances for barge transportation. The exact distance differs depending on the geographical situation, however, roughly distances below 50 kilometres can be defined as short range freight distance. Passenger transport focuses on urban public transit services and does in our understanding does not cover exclusively touristic services.

To reflect all relevant market segments and the regional distribution of good practice cases in the analysis, categories are defined based on literature research and interviews on existing services and perspectives for urban and short range IWT.[3] Relevant characteristics for the categorisation were discussed with selected urban and short-range IWT stakeholders and ports.[4] Existing studies, literature and interview partners refer to various services which either are in operation, are planned or have been in operation. The analysis derives some key market segments with a large number of urban and short-range services and relevant aspects for the categorisation of services.

2.1.2 Categories

Categories are defined based on key characteristics of services. Key characteristics are related to the market segment and the geographic location. The scope of the study is on passenger and freight operation. Due to their different characteristics these markets form the two categories passenger and freight.

As regards the distinction of market segments, a categorisation by route will be applied for freight while passenger operation is focused on urban environments. The study covers urban and short range IWT of freight which are distinguished. Market segments for both passenger and freight operation form different categories. For passenger operation the routing is the key characteristics. Pure river crossings and multi-call services are distinguished. Moreover, for freight operation the commodities and respectively logistics sector is relevant. The categories are building material, retail, parcel, waste, container, and mixed for services covering various commodities as well as other for services not belonging to one of mentioned sectors. For the analysis of services, the status is an important characteristic. The categories operational, pilot/living lab planned and discontinued are applied.

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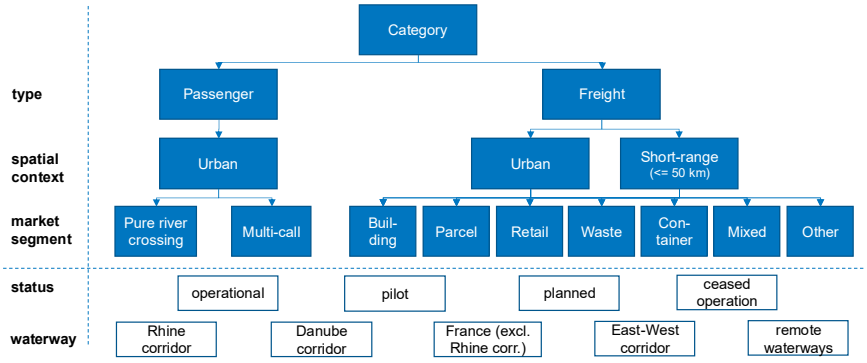
[3] See CCNR, Thematic report, An assessment of new market opportunities for inland waterway transport, Strasbourg 2022; Pauwels, et al., Market review on city freight distribution using inland waterways, publication in the framework of AVATAR, a project co-funded by the INTERREG North Sea Region programme 2014-2020 (ERDF), 2021.

[4] Interviews were carried out with the CCNR, HAROPA Ports, Shipit Logistics and Urban Waterway Logistics.

The regional distinction of services is important for the consideration of the IWT market conditions. Moreover, it is aimed for a regional balanced coverage of services. Therefore, the river basin / waterway corridor will serve as category. Rhine corridor, Danube corridor, France waterways off the Rhine corridor, the East-West corridor covering the North and East German waterway network as well as Czechia and Poland and other regions with remote waterways such as Sweden.

Figure 2.1 Overview of categorisation



The categorisation is used to cluster the identified services according to market segments, waterway region and status. All identified services are categorised correspondingly. This shows clusters with high activity in urban and short-range IWT. By doing this it will allow to consider a balanced coverage of different categories for the selection of the 20 good practice cases.

2.2 Evaluation

2.2.1 Approach

A two-stage evaluation is applied to correspond with the study objectives. First, a Quick-scan analysis is applied to analyse all identified services. This quick-scan is the basis for the selection of good practice cases. Good practices are determined based on the success of the concept proven by long-term operation and significant transport volumes contributing to modal shift to IWT and the mitigation of transport emission. These characteristics show the feasibility and the impact of the service. These are supporting factors for a transfer of concepts to other regions.

Moreover, smart concepts and innovative solutions either with respect to the organisation or implemented in any relevant service component may qualify a service as good practice. The same holds for effective policy solutions such as incentives and regulatory measures to strengthen the competitive position of IWT with respect to truck operation. Finally, considerations to compile a balanced and representative sample are relevant for the selection of good practice cases.

For selected good practice cases, an in-depth evaluation is carried out to analyse the services in detail and identify success factors for the development of urban and short-range services.

Quick-scan analysis

The Quick-scan analysis is based on available information gathered from literature and the survey among inland port representatives and stakeholders.[5] The focus is on the determinants for the

[5] See CCNR, Thematic report, An assessment of new market opportunities for inland waterway transport, Strasbourg 2022.; Pauwels, et al., Market review on city freight distribution using inland waterways, publication in the framework of AVATAR, a project co-funded by the INTERREG North Sea Region programme 2014-2020 (ERDF), 2021.

qualification as good practice case. The analysis will be based on the performance of services and concepts as well as solutions applied. The performance is linked to the successful operation of the service. Criteria to analyse the performance and identify good performing services are the maturity of operation and transport volumes as well as impact. As often figures are not available, the selection of good practice cases needs to be based on estimates or qualitative evaluations. Moreover, innovative concepts and solutions contribute to a good performance and are analysed regarding the possible consideration of services as good practice case. Innovative and sustainable concepts and solutions may include new solutions for logistic/passenger processes, vessels including clean propulsion systems, equipment, and business models etc. Considering promising services with innovative concepts and solutions in the planning and start-up phase, the Quick-scan analysis considers the innovative character of services. This allows to select promising services with innovative and smart concepts and solutions as good practice, irrespective of the status and performance. Services with a good performance and/or smart concepts and solutions may be selected as good practice.

The analysis is based on a qualitative assessment. As regards performance full data is not available for all identified services. The innovative character of applied concepts and solutions can only be analysed qualitative. As a result of the Quick-scan-analysis services with good performance and innovative concepts and solutions are identified. The selection of the 20 good practice cases focusses on proven good performing services but includes services with innovative concepts and solutions as well as ensures the representation of various market segments and waterway regions. This ensures a wide scope of the good practice cases and the results of their in-depth evaluation.

In-depth evaluation

The in-depth evaluation of good practice cases covers key characteristics for the feasibility of urban and short-range services.[6] It is aimed to analyse the good practice cases to draw conclusions regarding recommendations for the development of this market segment. The analysis includes the identification of success factors and solutions for the mitigation of barriers which contribute to the viability of concepts and business models as well as their successful implementation and transfer. In the cases various elements are relevant for the performance and feasibility of services and the qualification of services as good practice cases.

The conditions are similar for freight and passenger operation in urban environments and on short distances. The cost structure and performance of IWT which is in favour of long-distance transport of large volumes without any transit time requirements need to be adapted to the requirements in urban and short-range markets. Moreover, there is strong competition from road transport and from other public transport modes in passenger transport, too. Therefore, smart, and efficient solutions are required for the feasibility of urban and short-range services. This applies to all components relevant for the establishment of services. The growing interest in the mitigation of transport emissions, noise and congestion contribute to an improving environment for the establishment of services which need to be materialised by effective concepts.

Logistics, vessel, and transshipment are key elements of urban and short-range IWT concepts. These elements have to be adapted to the demand and the available infrastructure. All these components must be combined in a feasible business model which is competitive to truck transport. As regards passenger transport, waterbus concepts may contribute to the good accessibility of the city without

[6] See Janjevic, M., Ndiaye, A. B., Inland waterways transport for city logistics: a review of experiences and the role of local public authorities, WIT Transactions on The Built Environment, Vol. 138, page 279 -290, 2014, < https://www.witpress.com/elibrary/wit-transactions-on-the-built-environment/138/26144>; Polis, WATERWAYS AND URBAN LOGISTICS: HOW CAN REGULATIONS BETTER INTERCONNECT THE MODES?, Workshop documentation, Bruxelles July 2022;

congestion. In some cities passenger IWT networks are in operation as part of public transport. The density of waterborne networks depends on the extent of waterways and the population density as well as the land use near waterways.

2.2.2 Evaluation Criteria

The specific market conditions determine relevant components for the development of urban and short-range IWT services. The following key characteristics have been determined and will be analysed as separate criteria:

Table 2.1 Evaluation criteria

Criteria	Context
Administrative requirements	The legal framework determines regulative and administrative requirements for the set-up of urban and short-range IWT services.
Transport demand	Transport volume and potential of the market which can be acquired are an indicator for the performance of services. Requirements and flexibility of the service with respect to transport volumes and structure of freight flows and passenger movements in terms of frequency, lot size and routes are relevant for the implementation.
Infrastructure	Infrastructure conditions determining operation in terms of accessibility as well as transhipment options and passenger stations. Requirements are related to the IWT concept.
Vessel	Vessel characteristics influence the suitability for logistic and transport requirements and has an influence on the sustainability.
Logistics/Coordination	The logistics coordinating the transport chain including IWT, transhipment, last mile and other logistic services determine the efficiency of urban and short-range IWT. For passenger operation, logistics refer to the coordination with public transport networks.
Competitive position	Alternative transport options and their performance and cost are the benchmark for IWT concepts. Apart from private cost, social welfare and public acceptance of transport and logistics are relevant. Societal gains may be the reason for public support for IWT services and restrictions for truck operation.
Business model	A promising business case and the economic feasibility of the IWT concept are important for a sustainable business model for urban and short-range IWT. Investment needs influence the risks associated to business models.

These evaluation criteria are evaluated qualitatively and classified on a three-level scale. The qualitative evaluation covers all relevant elements and a qualitative analysis including quantitative data, if possible, to explain the classification.

Considering that the analyses cover good practice cases and aim for the identification of superior solutions and concepts for the various elements of urban and short-range IWT services a standardised three-level scale is applied. The scale including “++: Very Good”, “+: Good” and “0: Average” is applied for the evaluation criteria. The evaluation focuses on the performance, impact and innovative character as well as the roll-out potential of services. The scales refer to the contribution of service characteristics to these categories.

Based on the qualitative evaluation the characteristics are evaluated on a scale as “Average”, “Good” or “Very Good” indicating the performance of service components with respect to the feasibility of urban and short-range IWT operation.

- **Administrative requirements**

The administrative requirements to set up urban and short-range IWT services are determined by the legal framework and its implementation. They may hamper the implementation of IWT services. The concept of the service determines the requirements for the approval of services. Hence, easy concepts within existing regulation facilitate the development of services. This will contribute to implementation with no further administrative requirements or allow an easy approval of urban IWT operation and transhipment as well as flexible operation without major restrictions. Relevant aspects may include the approval of certain equipment and new technologies, specific navigation requirements and the use of quays as well as shore-side sites. Another administrative issue may be the structure of port dues and other charges.

This criterium is evaluated with “Very Good” for services which benefit from a smooth administrative process. Concepts evaluated as “Good” expect minor administrative requirements. “Average” concepts face more administrative requirements.

- **Transport demand**

The transport demand and potential of services is an indicator for the performance of a concept and the correspondence with logistic requirements and respectively commuter needs. Substantial demand in urban environments and/or over short distances is a proof of concept in this market segment. With respect to the implementation of services the flexibility with respect to the transport volumes is another factor. It is analysed, what is the minimum in terms of volume considering lot sizes and required frequencies for the feasibility of services. Moreover, the possibility for scaling up services in case of increasing transport volumes is addressed.

Services are evaluated “Very Good”, if substantial volumes have been acquired and/or high flexibility exist with respect to the demand pattern required for the feasibility of the service. “Good” concepts perform weaker, but still allow the feasibility of services with limited volumes or without specific limitations. “Average” concepts do not include specific concepts to adapt to low transport volumes and/or specific requirements.

- **Infrastructure**

The infrastructure is a critical issue for the development of urban and short-range inland waterway transport services. Navigation conditions are often challenging and limit the dimension and draught of barges. This limits the payload of barges and threatens the feasibility of services. Often major limitations arise in urban environments with its narrow and shallow waterways.

As regards transshipment, sites for the handling of cargo are lacking along waterways. This applies to ports, but in particular to inner city locations which are essential for the establishment of urban IWT services. Concerning the availability of transshipment sites for urban operation conflicting interest contributes to the scarcity. There may be restrictions for cargo handling due to the proximity of housing and other non-industrial land use. Moreover, cities may be concerned that logistic operation at inner-city waterways may adversely impact their touristic value. This holds for cities with waterways running through historic areas such as old towns with a high interest among tourists.

Moreover, for the establishment of new locations such as in particular urban environments the lack of adequate handling equipment is another barrier. However, for the establishment of urban IWT services and logistic utilisation of inner-city locations discharging and loading of cargo needs to be

enabled. This require either shore-side equipment, fixed installed or mobile, or on-board equipment installed on barges. Dedicated quays and respectively bridges are required for passenger operation.

Due to the challenging infrastructure conditions, the requirements of an urban and short-range IWT service in terms of infrastructure are an important evaluation factor. The service is evaluated “Very Good” regarding infrastructure if the concept is specifically adapted to limited infrastructure conditions, and the service can basically operate in all waterway conditions and is flexible with respect to transhipment locations. This contributes to the feasibility of services and its easy transfer to other locations. “Good” is the evaluation for services with concepts which well adapts to any infrastructure conditions. good practice cases without any specific solutions for coordination with the infrastructure are evaluated as “Average”. This evaluation means that infrastructural barriers for the implementation of services may exist and limit their flexibility.

- **Vessel**

The vessel to be used is another important determinant with respect to the implementation of urban and short-range IWT services. There are a wide range of relevant factors to be considered.

For the vessel it is essential to be designed for the operation along the served waterways and in the ports. As regards freight transport, the vessel needs to be suitable for the market segment and commodities. The carried cargo determines design requirements for the vessel. Depending on the logistic concept and available shore-side facilities at transshipment locations additional requirements regarding equipment may arise. Adequate equipped vessels are needed to implement the logistic concept considering shore-side facilities. For passenger transport, the number of passengers is an important factor for the selection of the vessel. The waterways and ports usually limit the possible dimension and draught of the vessel. This applies to small urban waterways. The vessel should correspond with the requirements in a best possible way.

Moreover, the vessel is an important factor with respect to operational efficiency. The use of modern vessel with advanced equipment and a high level of automatization would allow to strengthen the operational efficiency. In the future, automatization may allow to operate with less crew onboard and could reduce operational cost significantly. Many urban and short-range IWT concepts work on the utilisation of autonomous vessels operation. This will strengthen the competitive position and contribute to the feasibility of IWT services.

The propulsion and fuel concept determines the environmental efficiency. The use of alternative fuel contributes to future readiness of the logistic concept considering increasing ambitions to mitigate emissions. Moreover, the mitigation of emissions is important for the public acceptance and support of concepts. This applies to urban environments with densely populated areas near waterways. The flexibility of the logistic concept with respect to the deployed vessel may facilitate the implementation. It is easier for a start-up to charter and respectively purchase an existing vessel for rather competitive rates. However, there might be a trade-off with the efficiency of a modern and/or customised vessel concept.

The use of an advanced vessels fully adapted to the market segment and logistic concept allowing efficient operation using alternative fuels scores best (“Very Good”). A vessel which is partly adapted is evaluated “Good”. Concepts with the use of vessels without specific installations and equipment for the operation are evaluated with “Average”.

- **Logistics**

The design of the logistic concept is an important factor with respect to the operational efficiency. The organisation of the full logistic chain should allow for seamless transport operation according to the needs of shippers. The requirements vary between market segments and commodities. This includes suitable concepts for the development of transhipment locations, handling of cargo and last mile operation. The extension of inland waterway transport as close as possible to origin / destinations e.g. in urban environments strengthen the operational efficiency. The planning of transshipment is linked to available handling facilities and last mile operation. As regards handling the characteristics of cargo and loading units need to be considered. The deployment of advanced concepts including innovative cargo vehicles could facilitate the transhipment process and last mile transport. Easy transhipment and handling strengthen the connectivity of service concepts and facilitate their implementation e.g. in urban environments.

Last mile operation is a critical factor in terms of feasibility and efficiency of services. The last mile concept needs to correspond with local regulation with respect to noise and air emission and to be organised efficiently considering the high share of last mile cost. The use of advanced solutions can strengthen the operational efficiency. This includes digital applications to manage the logistic chain real-time and the automatization of processes along the supply chain. A success factor for urban and short-range IWT could be the integration of value-added services allowing for the strengthening of the supply chain by shippers. This could include the organisation of city distribution and/or collection of cargo as well as the refinement of cargo.

The IWT concept will be evaluated “Very Good” when fully customised advanced high performance logistic processes allowing for seamless operation have been designed. These include coordinated processes for transshipment, handling, and last mile according to requirements. Partly optimised concepts with good integration of the transport chain are evaluated “Good”. Standard logistic processes providing working solutions are evaluated as “Average”.

- **Competitive position**

Urban and short-range IWT face strong competition from truck transport. The cost structure of IWT benefits from the transport of large cargo volumes over long-distance. However, in urban and short-range IWT the distances are generally short and cargo volumes are smaller. Therefore, the competitive position of IWT in terms of cost is challenging. However, restrictions for truck operation in cities could be strengthening factor for IWT concepts contributing to a better performance by IWT. With increasing distance of short-range operation railway is a competitor, too. In general, the performance is important for IWT concepts to outperform other modes. This may include a higher transport reliability by avoiding congested road networks to a large extent. Perspective potentials resulting from the use of autonomous vessels and the digitisation as well as automatisation of processes to strengthen the competitive position of IWT services should be considered.

Apart from the business perspective, the social benefits of IWT needs to be considered for the competitive position of IWT concepts. Social cost including external cost should be relevant to assess the competitive position. The avoidance of truck operation in urban environments and beyond contribute to the reduction of traffic congestion, the mitigation of emission and the improvement of living. As a results, in cities substantial social benefits are generated and the public acceptance of transport and logistics is enhanced. This is among other essential for inland ports and waterborne logistics. There is a need for green transportation to ensure the future of ports, the support from the local population and from policy. The social benefits may be the reason for granting subsidies which would then strengthen the competitive position in terms of operational cost.

For the evaluation, operational cost, performance and social benefits needs to be considered. An IWT concept which strongly outperform truck operation scores best (“Very Good”). IWT concepts with a superior competitive position to truck are evaluated “Good”. IWT concepts without a competitive advantage to truck are rated as “Average”.

- **Business model**

The business model is important for investors and operators to implement a sustainable IWT concept. Contributing factors are the feasibility of IWT operation considering any public funding and subsidies as well as the financing of required start-up investment. The business model benefits from sufficient revenues to cover cost. Revenues depend strongly on the competitive position of the IWT concept. The commitment by shippers and logistic service providers contribute to the expectation of sustainable revenues. The revenues need to be sufficient to cover the full cost including capital and operational cost. Moreover, start-up investment requirements are relevant as they determine the required capital which is linked to the risk of the business model.

The feasibility of the business model is improved by any public funding and subsides. These may be granted by authorities to strengthen IWT concepts with the objective for modal shift from road to IWT and a reduction of emission. With respect to start-up investment the financing of required capital is a relevant aspect. The business model is more attractive if investors are willing to provide the required financing. The support by public stakeholders may facilitate the financing and improve the conditions of debt financing.

A promising business model with strong stakeholder commitment and (the expectation of) cost-covering revenues as well as beneficial financing is evaluated “Very Good”. Feasible business models with less commitment and more risks are evaluated “Good”. Standard IWT business models are evaluated as “Average”.

3 Task 2.2 Existing services and Good Practice Cases

3.1 The Identification of urban and short-range IWT services

As part of the Green Inland Ports study, a survey was conducted whose recipients were inland ports and stakeholders with links to inland ports and inland waterway transport. This survey also aimed for the identification of urban and short-range IWT services and projects as well as gathering of information regarding this market segment.

Additional to the survey extensive desk research was carried out to complete the overview of urban and short-range IWT services and projects.

The collected data include details on the specific urban and short-range services such as the market segment and the operational status. Moreover, it was aimed to collect characteristics such as the launch year, the route network and the frequency of the service as well as details on the deployed vessel, especially the propulsion, and the financial support. These characteristics were used for the selection of good practice cases.

In total, 69 freight projects, 18 passenger project and 1 project designed for both passenger and freight transport have been identified. Most projects are operational. The 69 freight projects cover various market segments:

- 13 urban IWT services for retail
- 22 urban / short-range IWT services for building materials
- 8 urban IWT services for pure urban parcel deliveries
- 12 IWT service for waste
- 12 IWT services for mixed freight
- 2 short-range IWT services for containers

The survey and research resulted in the following long list of services in the EU. Freight services in the market segments building material, parcels, retail (including food & beverages) and waste, passenger services as well as mixed cases for both freight and passenger transport were distinguished.[7]

1. Building logistics

Project	Port/City	River Basin	Spatial Context	Status
Amsterdam Vaart	Amsterdam	Rhine	Urban	Operational
Antwerpen Multimodale Bouwlogistiek	Antwerp	Rhine	Urban	Pilot/living lab
Brussels Consolidation Centre	Brussels	Rhine	Urban	Operational
BMB Bouwmaterialen	Antwerp	Rhine	Urban	Operational
Valdelia Experiment - Cemex Granulat - Green Switch Meridian	Paris	France (excl. Rhine)	Urban	Pilot/living lab
Henleykai Campus	Ghent	Rhine	Urban	Operational
Lange Munt	Ghent	Rhine	Urban	Pilot/living lab

[7] See CCNR, Thematic report, An assessment of new market opportunities for inland waterway transport, Strasbourg 2022.; Pauwels, et al., Market review on city freight distribution using inland waterways, publication in the framework of AVATAR, a project co-funded by the INTERREG North Sea Region programme 2014-2020 (ERDF), 2021.

Project	Port/City	River Basin	Spatial Context	Status
Olympic Village Paris	Paris	France (excl. Rhine)	Urban	Operational
Point P	Paris	France (excl. Rhine)	Urban	Operational
De Krook	Ghent	Rhine	Urban	Operational
Maritime Campus Antwerpen	Antwerp	Rhine	Urban	-
Croix Rousse Tunnel	Lyon	France (excl. Rhine)	Urban	-
Barge fluviale de stockage déporté	Paris	France (excl. Rhine)	Urban	-
Grand Paris Express	Paris	France (excl. Rhine)	Urban	Operational
Le chantier de Notre Dame	Paris	France (excl. Rhine)	Urban	Operational
Le chantier du Grand Palais	Paris	France (excl. Rhine)	Urban	-
Spie Batignolles	Toulouse	France (excl. Rhine)	Urban	-
Lignes de tram	Liege	Rhine	Urban	-
Chantier Manufacture des Tabacs	Strasbourg	Rhine	Urban	-
Champs Elysee - footpath	Paris	France (excl. Rhine)	Urban	Operational
City barging	Amsterdam	Rhine	Urban	Operational
A26 Highway	Linz	Danube	Short-range	Operational

2. *Parcel logistics*

Project	Port/City	River Basin	Spatial Context	Status
A-Swarm	Berlin	East-West	Urban	Pilot/living lab
Blue Line Logistics (ZULU) / DHL	Ghent	Rhine	Urban	Pilot/living lab
Fludis	Paris	France (excl. Rhine)	Urban	Operational
DHL Hollands Glorie	Amsterdam	Rhine	Urban	Discontinued
Radkombitransport (RAKO) Donaukanal	Vienna	Danube	Urban	Pilot/living lab
Decarbonmile	Hamburg	East-West	Urban	Pilot/living lab
DHL Solar Boat	Berlin	East-West	Urban	Operational
DHL parcel delivery	Venice	Remote	Urban	Operational

3. *Retail logistics*

Project	Port/City	River Basin	Spatial Context	Status
Au fil de l'eau (Vert chez Vous)	Paris	France (excl. Rhine)	Urban	Operational
Beerboat	Utrecht	Rhine	Urban	Operational
Bioboot	Ghent	Rhine	Urban	Operational
City Supplier (Vracht door de gracht)	Amsterdam	Rhine	Urban	Operational

Project	Port/City	River Basin	Spatial Context	Status
Dentressangle/Franprix	Paris	France (excl. Rhine)	Urban	Operational
Ikea (Box2Home)	Paris	France (excl. Rhine)	Urban	Operational
La Garonne Fertile	Bordeaux	France (excl. Rhine)	Urban	Pilot/living lab
Smart Port Shuttle	Hildesheim	East-West	Short-range	Pilot/living lab
Amsterdam Logistics Cityhub	Amsterdam	Rhine	Urban	Pilot/living lab
Ikea	Vienna	Danube	Urban	Planned
ULS	Lyon, Strasbourg etc.	France	Urban	Operational
LIUM	Lyon	France (excl. Rhine)	Urban	Operational
InnoWaTr	Hamburg	East-West	Urban	Pilot/living lab

4. Waste logistics

Project	Port/City	River Basin	Spatial Context	Status
Centre Multimodal de Distribution Urbaine (CMDU)	Lille	France (excl. Rhine)	Short-range	Operational
Ecoboat	Utrecht	Rhine	Urban	Operational
River'Tri & FLAGSHIPS Lyon	Lyon	France (excl. Rhine)	Urban	Operational
Syctom	Paris	France (excl. Rhine)	Urban	Operational
Dechetterie fluviale	Paris	France (excl. Rhine)	Urban	Pilot/living lab
Mokum Mariteam	Amsterdam	Rhine	Urban	Operational
Afval Vlaams Braband	Vlaams/Antwerp	Rhine	Urban	Operational
Dencity	Gothenburg	Remote	Urban	Pilot
Plastic Whale	Amsterdam	Rhine	Urban	Operational
City Barge Waste collection	Leiden	Rhine	Urban	Operational
Afval Vlaams Brabant	Brabant	Rhine	Urban	Operational
Bek & Verbrug (ship waste collection)	NL: Rotterdam and other ports	Rhine	Urban	Operational

5. Mixed logistics

Project	Port/City	River Basin	Spatial Context	Status
Citybarge	Leiden, Delft	Rhine	Urban	Operational
FLAGSHIPS Paris	Paris	France (excl. Rhine)	Urban	Operational
Urban Logistics Cluster for Ile-de-France 2021	Paris	France (excl. Rhine)	Urban	Pilot/living lab
SmartWaterWay	Ghent	Rhine	Urban	Operational
Blue Line Logistics (Zulu)	BE/FR: Kapellen, Lyon etc.	Rhine / France (excl. Rhine)	Urban	Operational
Watertruck+	Flanders and the Netherlands	Rhine	Urban	Operational
Kotug E-push convoy (Cargill Zaandam cocoa supply)	Amsterdam region	Rhine	Short-range	Operational

Project	Port/City	River Basin	Spatial Context	Status
Danube Delta Villages	Romania	Danube	Short Range	Operational
Green Wave (Avatar)	Ghent / Hamburg	Rhine / East-West	Urban	Operational
Amsterdam City Logistics Hub	Amsterdam	Rhine	Urban	Planned
DigiPort	Berlin	East-West	Urban	Operational
CityPort	Utrecht	Rhine	Urban	Operational

6. Container

Project	Port/City	River Basin	Spatial Context	Status
Alphenaar Heineken	Alphen	Rhine	short-range	Operational
Decontrans	North-Rhine Westphalia	Rhine	Short-range	Planned

7. Passenger transport

Project	Port/City	River Basin	Spatial Context	Status
Taxi Boat by Batorama	Strasbourg	Rhine	Urban	Operational
Waterbus	Brussels	Rhine	Urban	Operational
Waterbus	Rotterdam	Rhine	Urban	Operational
RET Passenger Transport	Rotterdam	Rhine	Urban	Operational
Waterbus	Antwerp	Rhine	Urban	Operational
Tiber Cat Rome	Rome	Remote	Urban	Planned
GVB Amsterdam	Amsterdam	Rhine	Urban	Operational
Västtrafik	Gothenburg	Remote	Urban	Operational
HADAG	Hamburg	East-West	Urban	Operational
Prague Passenger Transport	Praha	East-West	Urban	Operational
Mahart – BKK Boat Service	Budapest	Danube	Urban	Operational
BVG Fährlininen	Berlin	East-West	Urban	Operational
SL Urban ferry	Stockholm	Remote	Urban	Operational
SL/Flying Boat	Stockholm	Remote	Urban	Planned
Havnebus	Copenhagen	Remote	Urban	Operational
Urban Water shuttle	Stavanger	Remote	Urban	Operational
Wasserbus	Cologne	Rhine	Urban	Planned
ACTV water transport	Venice	Remote	Urban	Operational

8. Freight / Passenger transport

Project	Port/City	River Basin	Spatial Context	Status
Roboat	Amsterdam/ St. Denis	Rhine	Urban	Pilot/living lab

3.2 The Selection of 20 Good Practice Cases

The services were analysed by means of a Quick-Scan Analysis using information from literature, interviews and the survey. The long-term operation, feasibility, impact, sustainability, and innovative character are key criteria for the selection as good practice cases. Moreover, it was considered to have a balanced sample representing various market segments and waterway regions.

As a result, the following services have been selected based on the outlined factors as good practice cases. The selection is balanced with sixteen freight and four passenger services and a wide coverage of market segments and waterway regions. The Table 3.2 gives an overview on the selection of good practice cases.

3.2 Selection of Good Practice Cases

Name	City	River Basin	Segment	Good Practice Factors
Highway A26	Linz	Danube	Building Materials	Example from Danube region. Obligatory use of IWT for disposal of excavated material specified in construction contracts.
Grand Paris Express	Paris	France (excl Rhine)		Large quantities over 15 years construction time / Expected transport volume of 45 mio. tons
Consolidation Centre	Brussels	Rhine		Since implementation 2019 440,000 truck-km were avoided
Waste Collection Budapest	Budapest	Danube	Waste	Established since 2016. Daily capacity of 16 tonnes (40 m^3) allows for significant mitigation of truck operation in inner city.
Invotis IV (Bek & Verbrug ship waste collection)	Rotterdam	Rhine		The service deals with shipborne waste in the Port of Rotterdam, Moerdijk and Dordrecht and has been operational for 55 years. Electric ship in operation.
Lille Waste	Lille	France (excl Rhine)		Well-established short-range service in operation since 1998. About 200,000 tonnes of waste are transported per year.
Retail Paris	Paris	France (excl Rhine)	Retail	Well established Franprix (B2B) and Box2Home/Ikea (B2C) services. 750.000 Truck km p.a. avoided
Beerboat	Utrecht	Rhine		Already established since 1996 / electric barges / 17 tons CO2 avoided per year
DHL Berlin / Amsterdam	Berlin / Amsterdam	East-West / Rhine	Parcels	Promising sample for parcel logistics in Berlin / involvement of DHL / Building on experience from Amsterdam
A-Swarm	Berlin	East-West		Small Innovative ship (autonomous modular operation); units to be coupled
ULS	Strasbourg / Lyon	Rhine / France (excl. Rhine)	Mixed	Cargo Bikes as Last-mile operator / partnership with GEODIS

Name	City	River Basin	Segment	Good Practice Factors
Cityport of Utrecht (Logistic Hub-Project)	Utrecht	Rhine		Promising logistic concept which aims to realising a network of Micro-Hubs. Significant reduction of urban truck movements.
Citybarge	Leiden, Delft	Rhine		Zero-emission (tank-to-wake at least), first of the bunch in small-scale logistics
Green Wave Avatar	Ghent/ Hamburg	Rhine/East-West		Small barge for urban operation. Innovative ship concept
Kotug E-push convoy (Cargill cocoa supply)	Amsterdam Region	Rhine		Short-range service / electric convoy
Alphenaar Heineken Boat	Rotterdam Region	Rhine	Container	First zero-emission ship within Western-Europe powered by electric engines with interchangeable batteries. The service is a good example for short-range container operation.
Flying Boat/ Commuter ferries	Stockholm	Remote	Passengers	Innovative Ship / Electric hydrofoil ferry / 5 mio. passengers p.a.
HADAG	Hamburg	East-West		8 mio. passengers p.a.
Waterbus	Rotterdam	Rhine		1.9 mio passengers p.a. / Electric ferries
Mahart – BKK Boat Service	Budapest	Danube		Part of public transport network in Budapest. Successful example from Danube region.

3.3 The Evaluation of 20 Good Practice Cases

The 20 selected good practice case are subject of an in-depth analysis. It will cover the evaluation criteria addressing key service characteristics. The analysis will be based on desk research, information collected in the Green Inland Ports survey and interviews with ports and stakeholders representing the services.

Additional to introductory interviews, interviews were conducted with various stakeholders from the case selection. These interviews were used to gain insights into the operation of urban and short-range IWT services, to discuss potentials and challenges and to collect data for further analysis. Moreover, the interviews were used to validate the evaluations with representatives of the services.

A template for the evaluation of the good practice cases was created to ensure a standardised representation of the research results. This template provides an introduction to the case and an overview of important key facts. Based on the selection of evaluation criteria, as created in sub-task

2.1, an assessment is carried out. The findings of this assessment are summarised in the conclusion as lessons learnt and as potential for replicability. In this way, each case can demonstrate the significance of its successes for the further development of the market segment. The template is also illustrated in the table below.

Table 3.3 Template of the in-depth analysis

No.	Section title	Brief elaboration of contents included
1	Introduction	The first section provides a frame for a brief introduction describing the service in more detail.
2	Key facts	The second section provides an overview of important key facts that describe the service. These include service details and refer to the categorisation of the service.
3	Assessment of the evaluation criteria	The main part of the analysis concerns the assessment of the evaluation criteria. • Administrative requirements • Cargo/passenger flows • Infrastructure • Vessel • Logistics/Coordination • Competitive position • Business model
4	Conclusion	In the last section, an outlook on the service perspectives can be given and lessons learnt can be drawn. What insights were gained in the service that provide important perspectives for the roll-out of services in other ports

The results of the evaluation of the 20 good practice cases within the framework of the template just explained are presented below. The good practice case profiles are grouped according to their market segments.

3.3.1 Good Practice Cases for urban and short-Range IWT Services for Construction Materials

Highway Construction in Linz

1. Introduction

The construction of the A26 highway in Linz covers a distance of 4.7 km, including 4 km of tunnels. Two bridges are being built on this stretch, including a 300-metre-long suspension bridge over the Danube. In total, this construction project consists of 3 stages. In the first two construction stages of the bridge and tunnel construction, waterborne transport will be used. This was ASFINAG's requirement in the tendering process to minimise noise pollution for local residents. The larger steel elements and the tunnel excavation were therefore shipped on the Danube. The tunnel excavation will be shipped to the Danube port of the Fuchshuber company in Lower Austria over 30 km. The contractor for the ship transport is the company JDK Ship Service from Bratislava. At the port, the material is removed by a manufacturer of concrete and asphalt aggregates and processed in a nearby plant in St. Pantaleon for the use in road substructures. In the area of the construction site, a mobile reloading station with a conveyor belt, which is loaded with lorries from the tunnel, was used for removal.

Image of the service

Excavation material loaded onto the vessel for transportation (Source: ASFINAG)

Key Facts			
Name of service	Highway Construction in Linz	Crew	3 per push boat
Operator	JDK Ship Service on behalf of ASFINAG	Automation	No Automation
Market Segment	Construction materials	Port equipment	Loading of excavated material via a mobile conveyer belt, discharging via excavators

Key Facts			
Region	Danube	Last Mile Transport	Truck operation by manufacturers for excavation material
Status	Operational	Return Flows	None/empty
Launch year	2019	Waterway infrastructure (Navigation Conditions)	Limitations due to bridges and lock, fluctuating unloading depth
Barge Capacity	1000 - 1200 t	Service frequency	c.a. 2 - 3 times per workday
Fleet Size	2x Push boats with 1-2 barges	Transport volume	About 800,000 t of excavated material in phase 1
Ship Length	70 m	Societal benefits (e.g. mitigated emission)	Drastic reduction in truck journeys
Draught	Minor limitations	Supportive regulatory framework	Specification for ship transport in the tender
Propulsion	Diesel	Financial support	No subsidies
Equipment	No special Equipment		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**
The entire highway construction project was subject to an environmental impact assessment. Waterborne transport was also an issue within this assessment, e.g. regarding noise emissions in the water. This is a standard process for federal highway construction projects. The loading point of the excavated material also had to be approved beforehand. So, the waterway transportation was predetermined in the construction process. A more complicated approval process was required for the transport of the large steel bridge structure, which had to be inspected 6 weeks in advance as a special transport and had to be accompanied by the waterway police, as the special transport restricted conventional waterway traffic. However, special transport by road would probably have been more difficult to regulate.	

Criteria	Evaluation
Cargo/passenger flows	**Very Good**
The transport volume of the tunnel excavation to date comprises 305,000 tonnes of excavated material in 2020 (218,000 m³, 275 barges) and 501,000 tonnes of excavated material in 2021 (358,000 m³, 451 barges). These quantities were created in construction phase 1 from the construction of the tunnel feeders for the bridge on the south side of the Danube. Only solid rock was extracted during this phase. Excavated material on the north side of the Danube could be transported by trucks without causing noise pollution for residents. In construction phase 2, the construction of the Tunnel, which connects the newly built bridge with the railway station in Linz, further transport volumes will be created for inland waterway vessels. In addition to solid rock, sand, slate clay, gravel and other sediments are also expected to be transported. A lack of storage capacity at the construction site due to the geographical	

Criteria	Evaluation
Cargo/passenger flows	**Very Good**
limitations of the Danube valley and mountain slopes made constant removal necessary. In addition to the tunnel excavation, the operation also included the transport of large bridge steel elements. A total of 9 bridge elements were transported to the construction site using pontoons and were hydraulically lifted into the steel cable construction. The individual elements had a length of up to 42 metres. Nevertheless, the transport of bridge construction elements accounted for a smaller proportion of the total volume compared to the excavated material.	

Criteria	Evaluation
Infrastructure	**Good**
The distance between the construction site and the waterway shouldn't be too long and is limited to a few hundred metres. However, this is particularly the case for river bridge constructions, which makes it possible to use IWT operation for such construction projects. Originally there was planned a fixed waterside loading point for the construction site. However, this concept was replaced with a mobile solution. This minimised the impact on the shoreline and only individual concrete foundations had to be poured for the conveyer belt construction. The conveyer belt, which loaded excavated material from the tunnel exit onto the ship, could be rented. As there was always a barge under the conveyer belt that was loaded, the ship was used as floating storage providing additional capacity that did not take up any additional space on the construction site itself. Nevertheless, the existing bank structure was also an obstacle, as the loading area was not deepened. Fluctuating water levels meant that barges could not always be loaded to 100% to prevent grounding. Nevertheless, it was never the case that low water levels stopped the transport completely. In the tunnel, trucks load the material onto the conveyer belt. For the transportation of large sized steel bridge elements locks have been a bottleneck.	

Criteria	Evaluation
Vessel	**Good**
Two push boats with 1-2 barges each were used both for the transport of excavation material and the bridge construction elements. The use of push convoys enabled flexible operation with a flexible capacity, which could be adapted to the excavation volume by the number of barges used in the push convoy. This enabled smooth transport, with barges being filled with excavated material from the conveyer belt and brought to a port in lower Austria 30 km away. Bridges in the city centre were a bottleneck for the steel bridge elements on the push boats. The lowest bridge had a height of 7.52 metres, and there was also a lock to pass with a length of 230 meters and a width of 24 metres. There were no other bottlenecks on the river, so that these conditions allowed for normal waterway traffic and normal sized freight barges. The push boats were powered by diesel engines. Construction projects for ASFINAG are lengthy processes due to its size. This is why the tendering process dates back a long time when	

Criteria	Evaluation
Vessel	Good

alternative propulsion systems did not have the same technical maturity. This is why this aspect was not relevant in the planning. In retrospect, this planning could not be changed, as this would require new testing procedures that would delay the construction period. In other future projects of this type, the electrification of a waterborne transport system would have to be examined separately. As these are standard but also flexible push convoys, that can adjust to different cargo flows using different number of barges, the concept offers potential.

Criteria	Evaluation
Logistics/Coordination	Very Good

In the course of tunnelling projects constant removal of the excavated material is necessary, as long delays can lead to interruptions in construction operations, especially as the construction site offered little space for temporary storage of the excavated material. The tunnel construction machines were in constant use, while transport was interrupted at weekends and on public holidays, which would also be the case with truck transport. However, this constant removal using IWT worked. The main logistical bottleneck in this process was the unloading of the barges in the harbour, where the excavated material was taken to a nearby plant. The material was recycled for the use in road substructures and as concrete and asphalt aggregate. The recycling of excavated material was a qualitative criterion specified by ASFINAG in the tendering procedure and has been established on the market as well. One option would have been landfilling, but this would have cost just as much money with less benefit.

The main reason for transporting the 9 bridge construction elements was the lack of space. The ship made it possible to transport pre-assembled units with a length of up to 42 metres. They were assembled on an area provided by a nearby power plant. This made it possible to transport them without having to pass through a lock. The steel elements were loaded onto pontoons and transported by push boat. This special transport had to be planned 6 weeks in advance. Hydraulic devices and steel cables were used to suspend the steel elements from the bridge.

In logistical terms, waterborne transport offered advantages over the space limitation. It was possible to transport the excavated material on time. The transport here was customised to suit the construction project.

Criteria	Evaluation
Competitive position	Good

The construction of tunnels requires the transport of large quantities, which is where the economies of scale of inland waterway transport come into play, as the proximity to the water means that transport is not only environmentally friendly but also reduces noise annoyance. Transporting the bridge elements also saved space compared to truck transport. Nevertheless, it can be ruled out that truck transport would have been more expensive. Waterborne transport was able to prevail as this was stipulated in the tender.

Criteria	Evaluation
Business model	**Very Good**
The stipulation of waterway transport in the tender is the basis for a working business model as long as the works are ongoing. Construction companies are required to contract barge operators without competition from other modes which contributed to the feasibility of the business model. Using the example of the ship transport company JDK Ship Service, the case offers a competitive business model in the field of waterborne bridge construction. JDK Ship Service is involved in several projects. These include bridges in Bratislava, Steyregg and Mathausen. A rarer topic is the integration of waterborne transport in the case of tunnelling. In the case of Linz, there were no subsidies from the public sector. ASFINAG was remunerated for the construction project based on the list with fixed prices per each performance of single services. The business model therefore works because the costs are covered by ASFINAG.	

3. Conclusion

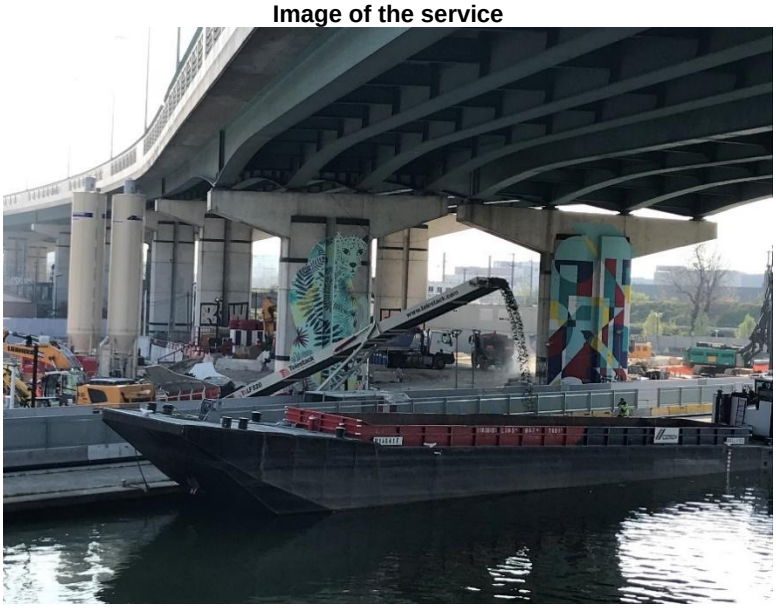
The use of waterborne transport of construction materials while tunnelling and bridge construction offers various advantages. In the context of this construction project, space savings and noise avoidance were decisive factors in the decision to use the inland waterway transport. Of course, in tunnelling, waterborne transport is limited to projects where the construction site is close enough to a waterway. If this is the case, there is also likely to be a lack of space in most cases, as tunnelling is most likely to take place in mountainous landscapes that are cut by rivers when close to water. However, the implementation requires planning in public tenders, as otherwise truck transport would be preferred in most cases. This option should therefore be considered when tendering contracts for major public construction sites near water. In Austria, there are currently no other fields of application of this kind in the near future, but other European large scale infrastructure projects could also serve as potential cases in future.

Grand Paris Express

1. Introduction

The Grand Paris Express is a major infrastructure construction project designed to improve transport links in the greater Paris area. In total, the rail network to be built is 200 kilometres long and 68 new stations are to be built. The efficient management of construction logistics is crucial to the success of the project, particularly in the removal of excavated material and the transport of important construction materials such as cement and further aggregates. Water transport is proving to be a key solution as it utilises natural waterways such as the Seine to manage the logistical complexity. Through partnership and innovative logistical planning between Societe du Grand Paris and other key stakeholders in waterborne transport such as HAROPA, joint solutions for a logistics concept have been developed. Based on this concept, the contractors Cemex and LafargeHolcim transport cement, aggregates and excavated material by water, thus illustrating the transport of construction materials in an urban environment.

Image of the service



Excavation material loaded onto the vessel for transportation (Source: ASFINAG)

Key Facts			
Name of service	Grand Paris Express	Crew	1 - 2
Operator	Cemex and LafargeHolcim on behalf of Société du Grand Paris	Automation	No Automation
Market Segment	Building Materials	Port equipment	Sorting platform in Bonneuil-sur-Marne, conveyer belts, jetties and quays
Region	France (excl Rhine, Paris)	Last Mile Transport	Trucks or conveyer belts
Status	Operational	Return Flows	Excavation material
Launch year	2016	Waterway infrastructure (Navigation Conditions)	High level waters, variable 1-3 weeks per year, statistically foreseeable.

Key Facts			
Barge Capacity	2500 t (on the Seine), 600 t (on the Canal Saint-Denis)	Service frequency	For each tunnelling machine (2000 t per day) one time per day
Fleet Size	Varies according to transport demand	Transport volume	7,4 % excavated material shipped (474,900 t in 2022)[8]
Ship Length	38 m (width 5 m)	Societal benefits (e.g. mitigated emission)	Mitigation of Co2 emissions and avoidance of noise and dust annoyance
Draught	Ca 3,20-3,90 m on the Seine and the Canal St Denis	Supportive regulatory framework	Partnership agreement between different stakeholder groups
Propulsion	Diesel	Financial support	Promotion by the Ile de France and by Voies Navigables de France (VNF)
Equipment	None special equipment		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**

Barges are subject to the usual navigation and safety regulations that apply to inland waterway transport; no further requirements are known. In terms of transport operations, waterborne transport and truck transport do not differ in terms of the necessary administrative requirements. The only difference is the guarantee that waters must not be contaminated with excavated materials during transshipment. Except the transportation process there are special regulations for the transported goods. Tunnel excavation is considered as waste, the transport of which is regulated by the Environmental Code. Because of this classification, it is intended for the tunnel excavation material to be minimised where possible, reused on site or nearby. If this is not possible, it is intended to valorise the material or store it for final disposal.

This also provides the framework for removal. Apart from this, there is a cooperation agreement between the Ile de France, the City of Paris, VNF, HAROPA, the Municipality of Paris for road construction and the Societe du Grand Paris signed in 2018. Under this agreement, Societe du Grand Paris undertakes to prioritise the use of inland waterway vessels for transport as part of the construction of the Grand Paris Express. HAROPA undertook to make its port network available. The City of Paris undertakes to offer important port locations. VNF undertook to provide advice and funding. The Prefecture undertook to

[8] https://www.grandparisexpress.fr/annual-report-2022

Criteria	Evaluation
Administrative Requirements	**Very Good**

participate in the financing. For a project of this scale, it is very important to involve all stakeholder groups to ensure efficient coordination.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

As of May 2022, the total amount of excavated material produced during tunnel construction was estimated to reach 47 million tonnes in total, at 2 tonnes per cubic metre. The target of transporting 15 - 20 % of the excavated tunnel material using alternative modes of transport was already set here. This is equal to more than 7 million tonnes of excavation. As of March 2023,[9] 12.8 % will be transported by ship and 1.2 % by train.

In 2022, 474,900 tonnes were transported on the waterway. At peak construction times, up to 20 tunnelling machines were in use. This peak has been exceeded and 66% of the excavation progress has already been completed for March 2024. The volume is expected to decrease, but at the same time an increase in the proportion of water transport is to be expected, as many construction sites with new contracts for the next construction phases are located near the waterways. In the future, the volume that will not be transported by road is expected to increase to 55-80%.

It is expected that around 10 million tonnes of excavated material will still have to be transported by water. It is therefore to be expected that the share of 15 - 20 % that should be transported by waterways in total will be reached. Transport volumes are flexibly adaptable due to the size of the ship convoys of 1 - 2 barges, whose cargo capacity of up to 2500 tonnes correlates with the daily quantity of excavated material of 2000 tonnes per day per drilling machine. At the same time, transport operators can adjust the fleet size. A construction site with a drilling machine has an intermediate storage period of up to five days. The tunnelling machines are in operation 24 hours a day, 7 days a week. To ensure efficient and cost-saving operation, there must not be any interruptions. The barge must therefore ensure the continuous removal of excavated material. At the same time, there are fewer fluctuations in transport demand.

Criteria	Evaluation
Infrastructure	**Good**

Due to the cooperation agreement HAROPA could provide infrastructure with locations that could be selected as transshipment platforms where quay walls already existed. This saved costs. Nevertheless, further adjustments were necessary. For example, additional jetties and storage capacities had to be installed at some locations. Conveyor belts had to be installed on all platforms. This is a disadvantage, as it represents additional costs that would not have been incurred for the truck transport operation.

Nevertheless, the maximum potential from these investments will be realised, as there are agreements with the City of Paris for subsequent use of the platform after the construction project is completed. The sorting facility in Bonneuil-sur-Marne played a special role, serving as a multimodal transhipment point for excavated material that could be transported from this

[9] Source: https://www.grandparisexpress.fr/travaux/environnement last access 27/2/24

Criteria	Evaluation
Infrastructure	Good

location to quarries in Normandy. The Canal St. Denis acted as a bottleneck, reducing cargo capacity and increasing costs per tonne due to locks and general space limitations for transports on this route. This made short-distance transport from the Canal St. Denis to transshipment platforms on the Seine particularly difficult. Although these short-distance transports reduced noise and dust emissions for local residents, they did not reduce CO2 emissions, which were primarily achieved by transports using the Seine only.

In summary, it can be said that additional costs served as challenges, but costs could also be minimised through cooperation with important stakeholders such as HAROPA.

Criteria	Evaluation
Vessel	Good

The IWT operations for the Grand Paris Express construction project employed a variety of vessels. The two operators of the waterborne transport either owned the ships themselves or chartered ships for the operation. The fleet consisted of barges with differing cargo capacities, adapted to operate both on the St Denis Canal and the Seine River. These barges, with lengths of up to 38 meters and widths of 5 meters, were designed to accommodate varying convoy configurations, ranging from single barges with a capacity of 600 tonnes for the navigation on the canal to larger convoys of 2 barges and a push boat with a capacity of 2500 tonnes for the navigation on the Seine.

The adaptability of convoy sizes ensured efficient transport operations across different waterways and cargo volumes. In terms of sustainability, the vessels primarily ran on diesel, reflecting the current industry standard. While diesel propulsion is effective for inland waterway transport, discussions with the Ministry of the Environment indicate potential future considerations for alternative propulsion systems, particularly in light of environmental concerns and events such as the opening ceremony of the Olympic Games scheduled on the Seine. However, the use of diesel-powered vessels was balanced against the project's overarching objectives, such as reliability, efficiency, and cost-effectiveness.

Overall, the vessel fleet employed for the construction project demonstrated adaptability and efficiency to changing navigation conditions.

Criteria	Evaluation
Logistics/Coordination	Good

The construction of the Grand Paris Express covers the entire area of the Ile de France. Crossed by the Seine, the Marne and several other canals, water transport can be used. Studies carried out together with SNCF have enabled Societe du Grand Paris to identify platforms from which it is possible to transport the excavated tunnel material by the waterway. Those transshipment platforms were located along the different Parisian waterways. One site near Gennevelliers will be used in future construction phases. With the involvement of

Criteria	Evaluation
Logistics/Coordination	**Good**

HAROPA, a sorting platform was built in Bonneuil-sur-Marne to process the excavated material for transport from the construction of Line 15.

All these measures ensured the seamless transport of excavation material. The quantities could be easily transported away at any time and the on-site storage capacities for the tunnelling machines were not overloaded.

Criteria	Evaluation
Competitive position	**Good**

The hight amounts of excavation material showed a logistical challenge in terms of removal and correspond to a large number of trucks that would place a heavy burden on the Paris transport system and the environment. Societe du Grand Paris is therefore endeavouring to use alternative modes of transport and incentives its contractors in the invitation to tender to use alternative transport modes like rail or waterway transport. This obligation was concretised in a joint partnership agreement between Societe du Grand Paris and the operators of facilities for the treatment, storage and recycling of the excavated tunnel material.

As a result, a "charter of good practice" was drawn up to ensure alternative modalities, traceability, recycling and disposal. This also includes financial incentives. Therefore, competitive position of waterborne transport was supported. There were competitive advantages over rail transport, because transshipment platforms for rail transport were often located in the vicinity of local residents, which would have resulted in dust and noise pollution. This could be avoided in some places by waterborne transport.

Criteria	Evaluation
Business model	**Very Good**

The business model results from the tendering procedure, which also favours waterborne transport through incentives. The contractors in this case are Cemex and LafargeHolcim, who supply the construction sites with cement and aggregates, which are very important for construction, but also transport the excavated material. LafargeHolcim supplies Paris with 860,000[10] tonnes of aggregates and cement for construction and Cemex with 550,000[11] tonnes of aggregates. Both companies use waterborne transport with barges. An important point of the successful business model is the tendering process, which favours modal change.

3. Conclusion

The implementation of water transport as part of the Grand Paris Express project has provided valuable insights for future urban infrastructure projects. Various challenges were overcome in the process. One of these was the logistical complexity of managing large volumes of excavated material and transporting construction materials at the same time. Another important aspect was compliance with standards of waste disposal regulations, which required careful planning. In addition, difficult

[10] Source: https://www.holcim.com/media/media-releases/lafargeholcim-grand-paris-transport-infrastructure, last access: 2nd of March 2024

[11] Source: https://www.cemex.com/w/cemex-provides-key-materials-for-the-grand-paris-express, last access: 2nd of March 2024

navigational conditions, especially on waterways such as the Canal St. Denis, posed a challenge for efficient transport operations.

One success factor was the formation of cooperation agreements with stakeholders such as HAROPA, which facilitated logistical planning and optimised operational processes. By involving stakeholders from the waterborne transport sector, the project benefited from their expertise and the infrastructure that HAROPA was able to provide in Paris and especially in the port of Bonneuil-sur-Marne. Another point that needs to be emphasised here is the adaptation of the tendering procedure in order to promote the potential of waterborne transport. Incentives were also offered in the tendering procedure to promote waterborne transport. This should also be taken into account in future large-scale infrastructure construction projects in order to utilise the potential in the future. One future major construction project that could be taken into account here is, for example, the construction of the Seine-Northern Europe Canal.

Brussels Consolidation Centre

1. Introduction

Shipit Multimodal Logistics is a Belgian company specialising in inland shipping, multimodal transport, storage and transhipment and urban logistics, with terminals in Brussels and Wielsbeke. Since 2019, Shipit has developed the Brussels Construction Consolidation Centre (BCCC), which now has 2 locations in Brussels. Deliveries of building materials are bundled at these locations. Building materials will be delivered to the Consolidation Centre by ship and then transported from one of the two locations by truck or barge to the end customer. Care is taken to ensure that there are no deliveries with lightly loaded or almost empty trucks to increase efficiency and sustainability of construction deliveries. In this way, truck journeys are saved or partially shifted to the waterways, which reduces noise and GHG emissions.

Image of the service

Deliveries of construction materials in Brussels (Source: Shipit)

Key Facts			
Name of service	Brussels Construction Consolidation Centre (BCCC)	Crew	2-3 crew members
Operator	Shipit, Port of Brussels	Automation	Digitalization of storage management and monitoring
Market Segment	Construction Materials	Port equipment	Forklifts
Region	Rhine	Last Mile Transport	Truck
Status	Operational	Return Flows	Waste, empty packaging, empty palettes and empty equipment
Launch year	2019	Waterway infrastructure (Navigation Conditions)	Canal between Brussels North and South, one lock on the way
Barge Capacity	1200 - 4000 t	Service frequency	ca. 14 Trucks per week
Fleet Size	12 barges	Transport volume	Equivalent of 600 trucks per week
Ship Length	80-105 meters	Societal benefits (e.g. mitigated emission)	220 t CO2 mitigation p.a., 49000 € in external cost savings p.a., since 2019 440,000 truck km avoided
Draught	3 meters if fully loaded (no relevant draught limitations)	Supportive regulatory framework	Limited restrictions for trucks in Brussel in the future

Key Facts			
Propulsion	Diesel	Financial support	Brussel port grants 1,5 €/t palletised cargo subsidy. In the first years the rent for the site and the warehouse was subsidised.
Equipment	On-board cranes for 2 ships, also trucks with cranes		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**
Administrative requirements do not play a major role for the BCCC and its service. There are no special administrative requirements as in other cases.	

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

In Brussels every week 20,000 trucks with construction material enter the city. 4000 of these trucks are suitable for using the CCC (some trucks are fully loaded; others bring material not suitable for the CCC). During the project lifetime until 2022 around 600 trucks out of these weekly 4000 trucks are routed via the CCC. The construction material is thus handled with more sustainable modes. This means there is further potential for volume growth and Shipit was able to further expand its market share in 2023. The potential is also demonstrated by a study on the feasibility of the BCCC. An average square metre of a construction site can require around 350 kg of new building materials, half of which comes from excavation work. A tonnage of 700 kg/m² is used for further simulations.

Considering active construction sites, it is estimated that the BCCC South will have an average transport demand of 3000 to 7000 tonnes per month until 2028. The number of construction sites is also expected to grow. In view of the forecast annual population growth of 9,000 to 10,000 inhabitants and the construction of 3,000 household units per year in Brussels, there is considerable potential for further volume growth. Shipit continues to adapt to these growing transport volumes every year by utilising additional chartered trucks. The fleet is currently sufficient.

Criteria	Evaluation
Infrastructure	**Good**

Brussels offers good infrastructure conditions for the service. The site in Brussels North can be accessed by all ships, meaning that ships with a capacity of up to 4000 tonnes can also deliver to the site. Construction materials from Antwerp are also delivered here via canals. The canals in Brussels offer sufficient draught. There is a lock in Molenbeek between the two BCCC sites in Brussels North and South. This represents a bottleneck for the shuttle that consolidates building materials between the two sites. Ships with a capacity of 4000 tonnes do not fit through the lock. The southern consolidation centre can only be approached by vessels with a length of 80 metres. This reduces the cargo capacity to 1,100 tonnes and increases the unit costs for transport on this route. There are sufficient quay walls at the locations, which enables an easy transshipment. The northern site has an area of 12,999 m^3 and a quay length of 160 metres and the site in the south of Brussels has an area of 2,000 m^3 and a quay length of 80 metres.

Criteria	Evaluation
Vessel	**Good**

Shipit charters ships and also operates its own fleet, that transport goods in France, Belgium, the Netherlands and Germany. Shipit has a total of 11 vessels. One of these is equipped with an on-board crane and additionally another vessel is also to be fitted with an on-board crane. Shipit also charters vessels from Blue Line Logistics, which were built by Sogestran. Shipit can use standard inland vessels for the service. An important expansion are on-board cranes, which also require an investment. For example, on-board cranes increase the acquisition costs per vessel by approximately €500,000 and increase the operating costs by 10-20% per vessel due to the elimination of transport space on the vessel. On the other hand, on-board cranes are of great importance in urban areas, because they also enable delivery to water edges without additional structural measures for handling for all construction sites that are located directly on the water.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

The logistics concept is based on the consolidation centres, which are supplied with building materials from various companies such as Knauf and Xella via waterborne transport. From this consolidation centre, construction sites within a radius of approx. 5 km can be supplied by truck as a last mile operation. It is being examined whether individual journeys can be bundled with truck to maximise the capacity utilisation per journey. It is also being examined whether journeys can also be made on the waterway if construction sites are located close to water sides. Truck cranes are important for truck operation to enable flexible loading of heavy construction materials. The digitalisation of warehouse logistics enables precise monitoring and simplifies the bundling of traffic. Incoming and outgoing goods are recorded transparently and the circulation of goods in the warehouse can be increased, thus enabling the efficient utilisation of warehouse capacities. The consolidation centre in the south of Brussels has been under construction for one and a half year. This extends the area within which deliveries can be made. With two locations in Brussels, Shipit can cover 70% of the population and

Criteria	Evaluation
Logistics/Coordination	**Very Good**
70% of construction sites. A concept for a third small location is also made for the delivery of parcels as a further business segment in the future.	

Criteria	Evaluation
Competitive position	**Very Good**
The BCCC offers an interesting logistics concept that aims to bundle transport by road and waterway, thus avoiding almost empty loaded journeys by increasing the truck capacity utilization by consolidation deliveries and making therefore a positive contribution to avoiding traffic jams, noise and CO2 emissions. Waterborne transport is not necessarily implemented or offered for every journey depending on whether construction sites located close to water. However, transport by waterway can be offered at the same cost as by road, which offers a good competitive situation. Nevertheless, both modes of transport complement each other in this concept rather than being in direct competition with each other. One way of reducing the costs of inland waterway transport could be to increase transport volumes in order to utilise economies of scale. BCCC's customers who are active in the construction industry are required to prepare carbon impact reports on their activities. In Europe, for example, companies that participate in emissions trading are required to carry out a carbon footprint assessment. In Belgium, there is also legislation that requires companies to include their carbon footprint in their annual report. This regulation makes the CO2 consumption of companies transparent and does offer a small incentive to reduce CO2 emissions in the transport of goods as well. This supports services as the BCCC, which aims for the reduction of emissions in transportation. Shipit is constantly improving its position in the overall market competition with its intermodal logistics concept in the construction industry.	

Criteria	Evaluation
Business model	**Good**
Since its foundation in 2019, the BCCC has been able to expand by opening another location in the south of the city, which will enable it to reach more construction sites. Additional business areas were also developed, such as the concept of “kitting”. This concept aims to minimise inefficient transport in the final stages of construction by bundling all the necessary materials into a comprehensive construction site kit to enable buildings to be completed at short notice. The support provided by government subsidies not only facilitates transport by waterway, but also offsets positive external effects such as the avoidance of noise and emissions. The Port of Brussels therefore grants subsidies of 1.5 euros per tonne or per pallet for transport via the waterways. The BCCC currently supplies several active construction sites in Brussels, which shows the demand for transport services, including construction sites as City Dox, the Erasmus Garden and the Tour & Taxi or the frequent delivery of street tiles for street	

Criteria	Evaluation
Business model	**Good**
construction sites. Important companies co-operate with Shipit as suppliers, including large manufacturers of building materials Xella, Marlux & Knauf	

3. Conclusion

The BCCC demonstrates the successful integration of inland waterway transport into urban logistics. By using two locations in Brussels for the consolidation of construction materials and subsequent distribution to end customers by truck or barge, it is possible to make transport more efficient and sustainable. The BCCC's consolidation concept also includes truck journeys for last-mile operations. Waterway transports are not necessarily carried out for every delivery but can be used if conditions are suitable. This offers a good competitive situation in which both types of transport complement each other. The digitalisation of warehouse logistics has helped to reduce costs and strengthen the competitive advantage.

Success factors include the targeted bundling of transports, investment in on-board cranes and the digitalisation of warehouse logistics. The main challenges are bottlenecks at locks. Nevertheless, the BCCC has developed successfully since it was founded in 2019 and offers additional services such as the “kitting” concept. Support from government subsidies and cooperation with important companies such as Xella also contributes to its success.

Shipit sees growing potential for the future in the BCCC business segment. The aim is not only to capture more market share in Brussels, but also to develop new locations. In Antwerp or Mannheim, the existing infrastructure offers the opportunity to implement similar consolidation concepts. Shipit also sees potential in Basel and has invested in shares in a port terminal. Furthermore, there is potential in every city that has various waterways running through it. One of the main challenges in this implementation is to gain local support.

In the future it can be expected that restrictions for road transport will be applied to reduce emissions and in favour of other transport modes such as bikes. In Brussels already today introduced restrictions for road traffic following the so called “Good move plan”. Any kind of restrictions increases the competitiveness of the BCC concept. With the two BCCs, Brussels is prepared for the future mobility in the region.

3.3.2 Good Practice Cases for urban and short-Range IWT Services for Waste

Waste Collection Budapest

1. Introduction

The service was launched in 2016. In a move to improve waste management and promote environmental responsibility, Budapest Public Space Maintenance Plc. and Mahart PassNave joined forces in the spring of 2016 to launch an innovative solution for garbage collection along the city's waterways. This collaboration introduced a garbage collection ship designed to not only alleviate road traffic congestion but also to contribute to the preservation of Budapest's natural beauty and appeal.

The ship can hold up to 16 containers, each with a capacity of 0.7 cubic meters. What makes this initiative truly remarkable is that these containers are discreetly stored within the ship, ensuring that the cityscape remains unspoiled. Inhabitants and tourists visiting Budapest will see nothing but a uniquely designed hull that blends seamlessly with the surrounding environment.

One of the key advantages of this garbage collection method is its efficiency. Unlike traditional waste collection vehicles that clog up roads and disrupt daily life in the city, the garbage boat operates quietly and unobtrusively on the water. This method significantly reduces traffic congestion and the associated environmental pollution.

Moreover, the environmental benefits are two-fold. Not only does the boat mitigate the impact of waste transportation on the city, but it also ensures the proper disposal of collected waste. With the assistance of experts from Főkert Zrt., the collected waste is unloaded at a newly established "green harbor" along Dráva Street. This modern waste management facility offers an environmentally friendly solution for waste disposal.

Image of the service

Source picture: https://hirado.hu/2016/10/10/leszerelt-katonai-naszad-takaritja-a-dunat/

Key Facts			
Name of service	Waste collection	Crew	1 +2 staff
Operator	Mahart PassNave	Automation	No automation

Key Facts			
Market Segment	Waste	Port equipment	No special equipment needed
Region	Danube (Budapest, Hungary)	Last Mile Transport	Truck
Status	In operation	Return Flows	Empty return flows
Launch year	2016	Waterway infrastructure (Navigation Conditions)	No navigational limitations
Barge Capacity	16 pieces of 0.7 cubic meter containers (8 tonnes)	Service frequency	Daily
Fleet Size	1	Transport volume	7-8 passenger vessels served in high season per day (30-40 m^2 per day)
Ship Length	17.5 meters long 4.72 meters wide	Societal benefits (e.g. mitigated emission)	Centralised waste collection, reduced noise pollution, not affecting the quayside, reduced road congestion
Draught	No relevant draught limitations	Supportive regulatory framework	None
Propulsion	2x280 kW Volvo engine	Financial support	None
Equipment	No special equipment		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**

There are no special administrative requirements for this service. The service is well established although there is no legal obligation to use the service. However, the service is well in line with the adequate requirements that shall smoothen the road traffic and safety on the Danube River banks downtown Budapest by means of reducing the number of vehicles on the road.

Criteria	Evaluation
Cargo/passenger flows	**Average**

The service is well established and used by many cruises and passenger ship, although there is no obligation to use the waterborne waste disposal service. The service does have a direct link to the waste disposal of passenger vessels such as cruise ships or daytrip vessels moored in Budapest. This requires a certain flexibility in transport operation adapting to fluctuating waste volumes, depending on how many tourist vessels moor in Budapest. Up to 16 tonnes at one day, was the highest transport volume which was reached. This shows a flexible adaptation of the service and efficient utilisation of the vessel's cargo capacity of 8 tonnes.

Criteria	Evaluation
Infrastructure	**Very Good**
The waste from the tourist passenger ships is collected via ship-to-ship transshipment. This reduces the need for infrastructural measures. This also means that traffic on the quayside is not disturbed which implicitly leads to a reduced environmental footprint due to less road traffic and less road congestion. Some adjustments had to be made at the other end of the transport chain. There is a dedicated mooring point, from where trucks transport the waste to city waste facilities. The complete project setup-costs were 200.000 € including infrastructure like pontoon and the vessel.[12]	

Criteria	Evaluation
Vessel	**Good**
The vessel is 17.5 meters long and 4.72 meters wide. The plastic and easily manoeuvrable hull enables an easy loading of waste from ship to ship. This increases the flexibility and efficiency of the service. The vessel is equipped with a 2x280 kW Volvo engines and has a waste load capacity of up to 8 tons. The waste disposal equipment onboard and the ship-to-ship transshipment, can be considered as success factors for the vessel concept.	

Criteria	Evaluation
Logistics/Coordination	**Good**
The service simplifies the logistics behind the waste collection and transport with reducing the number of trucks on urban roads. This contributes to the reduction of the congestion inside the city. This is possible thanks to a holistic logistics concept to which the ship is also adapted. For example, the ship has an easily accessible hull, which loads all relevant waste containers, which enables easy and efficient waste disposal directly from cruise and passenger ships to waste ship. It is obsolete to load waste onto the shore and there is no need to block mooring points for transshipment. The Tersus ship can collect waste from cruise and passenger ships and bring it to the disposal point where the waste containers can be emptied on the shore. In this way, the logistics concept helps to offer a business concept that meets the customer's requirements and can guarantee economic sustainability.	

Criteria	Evaluation
Competitive position	**Very Good**
Cruise and passenger ship operators welcome the service. The service could be considered as local competition to the conventional waste collection services by truck. However, the operation	

[12] Source: https://dailynewshungary.com/new-waste-collecting-ship-service-danube/, last access 8th of April 2024

Criteria	Evaluation
Competitive position	**Very Good**
of the service is rolled out together with the public utility company, thus basically it creates added value by “relocating” the transport route from the road to the river. In this way, the service proves itself in competition with other modes of transport and helps the city to cut CO2 emissions and reduce truck traffic in the city, since the need for truck waste transportation is reduced. The service in Budapest is well established in competition with various similar services along the Danube that meet the needs of cruise ships.	

Criteria	Evaluation
Business model	**Very Good**
This service, which is operated by Mahart PassNave, was created in cooperation between the ship operator Mahart PassNave and the public waste disposal operator. This collaboration opened an exploitable gap in the market and made the business case possible. The concept can be operated without additional financing since 2016 and does not rely on subsidies at all, which proves its economic sustainability and thus speaks in favour of its replicability.	

3. Conclusion

The municipality and the users welcome the service and advocate its benefits both on the logistics side and the environmental impacts. The service is highly welcomed by the end users. Stakeholders value the good reputation by the media and the public since 2016. The service package including the vessel and its mooring place is a good example of a well-designed and rolled out urban IWT solution. The service has potential for roll-out in other cities as well, however, potential competition with similar services in other cities needs to be considered, since when disposing the waste in Budapest, the same vessel does not necessarily need to use other services in other cities along the Danube. A coordinated network design along the Danube River with waste disposal services in some agreed and selected cities might be more efficient. A concept for waste disposal along the Danube (not only for house-hold waste, but also for oily and greasy waste) was developed in the WANDA and CO-WANDA projects earlier which might be of relevance to revitalise.

Invotis IX (Bek & Verbrug)

1. Introduction

Bek & Verburg has been active in ship and offshore waste collection in the Dutch seaports for almost 60 years. Bek & Verburg are offering a service desk for the collection of all ship-generated waste, including administrative procedures and coordination with the harbour authorities as well as all environmental services required during a ship's stay and before its departure from the port. With branches in Rotterdam, Scheveningen, Amsterdam, IJmuiden, Den Helder and Eemshaven, the company is Europe's largest ship waste collector.

The Rotterdam-based waste collector launched the Invotis IX as part of the fleet in 2016. Except for the crane, the Invotis IX looks just like Bek and Verburg's other Invotis ships on the outside. Sailing and collection with this collection vessel designed by Bek & Verburg itself runs electric. The Invotis IX has two diesel engines and one electric motor. This enables the ship to sail electrically for more than three hours where the electric motors are powered by batteries. At that point, there is zero emissions propulsion. During recharging, the ship sails on Gas To Liquid (GTL) which is a cleaner form of diesel that ensures fewer emissions and hardly any soot emissions. With this, the company is taking an important step. The use of emission-free vessels drastically reduces air pollution and CO2 emissions.

Image of the service

The Invotis IX berthed in Rotterdam.

The Invotis IX operates relatively silent because of the electronic crane that hoists the rubbish off the ship. Complaints from residents are to be avoided. Many residential towers have sprung up on the Wilhelminapier in recent decades. Residents, who often paid top prices, are not happy about noise, stench or traffic under their homes. The hybrid Invotis IX has an Atlas 350MH on deck, whose diesel engine has been replaced by an electric motor. The Atlas 350MH handler has the perfect articulated configuration and is built low, so that there is a good view of the hold. Moreover, it has a height-adjustable cabin as standard. This makes it possible to get closer to cruise ships with overhanging sloops and saves 2 hours for the waste disposal from cruise ships. After the Costa Concordia cruise ship disaster, the rules for lifeboats were tightened and now they hang lower. Consequently, they got in the way when disposing of waste and Bek & Verburg needed much more time for waste collection from cruise ships using existing ships in order to prevent the crane from hitting the sloops. The Green Award Foundation has awarded a platinum label to Bek & Verburg for the Invotis IX. This label, especially for inland vessels sailing emission-free.

Key Facts			
Name of service	Invotis IX (Bek & Verbrug)	Crew	2
Operator	Bek & Verburg	Automation	No
Market Segment	Waste (cruise ship waste collection)	Port equipment	-
Region	Rhine (South Holland, Rotterdam)	Last Mile Transport	-
Status	Operational	Return Flows	No
Launch year	2016	Waterway infrastructure (Navigation Conditions)	Rotterdam port area
Barge Capacity	About 90 cubic metres	Service frequency	On demand
Fleet Size	1 (Invotis IX)	Transport volume	-
Ship Length	42 m	Societal benefits (e.g. mitigated emission)	Zero emissions and reduction of noise
Draught	2.65 m	Supportive regulatory framework	Harbour Waste Plan for European sea ports Platinum Label Green Award
Propulsion	Main engine 690hp 2 x 345 pk Baumüller Electromotor.	Financial support	No
Equipment	Atlas 350MH crane		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**
The vessel fits well within the new Harbour Waste Plan for European sea ports. This plan has created a new sense of urgency to the collection of ship-generated waste. By placing into operation its new Harbour Reception Facilities (a licensed multipurpose recycling centre including quay facilities in the Rotterdam Botlek section), together with a comprehensive renovation and modernisation of its fleet, Bek & Verburg is well prepared to meet the significant new international challenges arising in the collection of ship-generated waste.	

Criteria	Evaluation
Cargo/passenger flows	**Good**
The Invotis IX specialises in collecting waste from cruise ships. Cargo flows are on demand and are strongly related to the frequency with which cruise ships call at Port of Rotterdam. Normally, a cruise vessel such as for instance AidaPrima leaves behind 90 cubic metres on its weekly visit to Rotterdam. Not every seaport has waste collectors who come alongside with a ship. Mostly, crews often have to drag the rubbish off board themselves to a waste station on shore a few hundred metres away. That means they save heavy items like broken washing machines until they reach Rotterdam. Bek & Verburg mentioned in an interview that sufficient frequency of waste collection (demand), and sufficient waste volumes (mass), are required in order to provide this relatively expensive	

Criteria	Evaluation
Cargo/passenger flows	**Good**
service in an economically feasible way. The company was not able to provide concrete figures for this. However, with a possibility of 30 ships per day that can be emptied one after another, Bek & Verburg's waste collection service is much more efficient than former truck-based operation. The cruise traffic at Port of Rotterdam provides a substantial market volume.	

Criteria	Evaluation
Infrastructure	**Good**
The infrastructural requirements for Bek & Verburg's marine waste collection service are comparatively low. Loading the ship's waste does not require any special infrastructure, as the Invotis IX's special crane can lift the waste safely and effectively from the ship. In general ship-to-ship transshipment saves infrastructural requirements. This reduces potential bottlenecks during loading and ensures that the waste collection service runs smoothly. Adapting the service to the existing infrastructure therefore requires no additional investment or customisation. The Invotis IX can be used flexibly in different harbours to carry out waste collection effectively while complying with environmental regulations.	

Criteria	Evaluation
Vessel	**Very Good**
The Green Award Foundation awarded a platinum label to Bek & Verburg for the Invotis IX. This label, especially for inland vessels sailing emission-free. Next to emission-free, the vessel is also silent. The Invotis IX can collect and transport large quantities of marine debris, making it a cost-efficient and effective solution for waste disposal. The ability to reach hard-to-reach places due its on-board crane also contributes to its competitiveness. Further, the hybrid ship has a special developed crane with a folding arm, which allows it to come closer to cruise ships with overhanging sloops, thus enabling an efficient transhipment. However, possible limitations in the navigability of waterways, such as low bridges or narrow channels, could affect the efficiency of ship operations. Bek & Verburg mentioned the acquisition costs of the boat were about EUR 3-3.5 million.	

Criteria	Evaluation
Logistics/Coordination	**Very Good**
With the ability to sail around and collect waste of several ships throughout the day, this type of service is way more practical and time efficient as compared to trucks, which have to drive on and off again. Almost all waste materials can be transported by Bek & Verburg and are reused, which further increases efficiency. Only seven percent goes to landfill. Bek & Verburg described that Invotis IX and other waste collection vessels discharge the waste at the end of the day at	

Criteria	Evaluation
Logistics/Coordination	**Very Good**
the Botlek, where everything is prepared for the waste processing. This processing happens at many different locations. There are about 700 different flows, which concerns mostly recycling but some waste is burned as well.	

Criteria	Evaluation
Competitive position	**Very Good**
The competitive position of Bek & Verburg's Invotis IX compared to other modes of transport such as trucks is favoured by several factors. One advantage is the ship's efficiency and capacity. Another advantage is the ship's environmental friendliness, as it causes no emissions or noise pollution. This is particularly advantageous in areas of the harbour with residential functions, such as the Wilhelmina Pier in Rotterdam. As a result, the Invotis IX can gain greater acceptance among the population and minimise potential complaints about noise and environmental pollution. As compared to in the past, there is barely any trucking in cruise ship waste collection in the Port of Rotterdam as of now except from hard-to-reach places where Invotis IX's (or another ship's) lifter cannot reach the cruise ship. The current service thus largely replaced the former truck-based operation. However, there are also some disadvantages that could affect the Invotis IX's competitive position. These include the ship's limited range compared to trucks, which are more flexible in terms of route planning and delivery to different locations. In addition, possible limitations in the navigability of waterways could weaken the competitive position. Overall, Bek & Verburg's hybrid Invotis IX offers an environmentally friendly and efficient alternative to transporting waste by ship, which strengthens its competitive position compared to other modes of transport and outperforms truck operation.	

Criteria	Evaluation
Business model	**Very Good**
The Invotis IX operates in a niche market. Competition is limited, ships are obliged to have their waste processed by a drop-off point. Currently, good facilities are often still lacking in other ports, so waste is sometimes saved for the Port of Rotterdam. The service does not rely on public subsidies whatsoever. For years, Bek & Verburg as a private company have financially covered the service themselves, so not to be dependent on external impulses such as sustainability funds. The economic feasibility is thus rated as decent.	

3. Conclusion

For almost 60 years, Bek & Verburg has been operational in the collection of ship-generated waste in the ports of Rotterdam, Dordrecht and Moerdijk. In 2000 the company expanded its operations to the entire North Sea Channel area (Amsterdam, IJmuiden etc.). In addition to this coverage of ports, the company is planning to offer its services in all Dutch ports.

Bek & Verburg also specialises in various cleaning operations for push barges, lighter barges and seagoing vessels and the treatment of damaged goods and cargo residues, including all required onsite operations. Crane vessels, push barges, and cleaning equipment are backed up by a large barge and/or vehicle fleet, enabling the company to provide a complete range of services to its

customers, 24 hours a day, 7 days a week. The implementation of the new Harbour Waste Plan for European sea ports has created a new sense of urgency to the collection of ship-generated waste. Further, the Shipping Waste Convention, which dates from 2009, requires shippers, stevedores and the like to deliver a ship clean. Since last year, the National Police Services Agency (KLPD) has been enforcing the convention and those involved are required to have an unloading declaration. The aim is to ensure that no more cargo residue enters the water. Stricter regulations on ship-generated waste, including a discharge ban on Marpol Annex 5 substances, are under way in Europe.

By placing into operation its new Harbour Reception Facilities (a licensed multipurpose recycling centre including quay facilities in the Rotterdam Botlek section), together with a comprehensive renovation and modernisation of its fleet, Bek & Verburg is well prepared to meet the significant new international challenges arising in the collection of ship-generated waste. Bek & Verburg has been officially appointed by Port of Rotterdam N.V. (The Rotterdam Harbour Authority) as collector of Marpol Annex V waste.

The roll out potential lies in the implementation of the new Harbour Waste Plan for European sea ports, which created a new sense of urgency to the collection of ship-generated waste. Similar uses are possible in other ports. In inland shipping, waste disposal is better regulated than in maritime shipping. Low-noise operation and zero emissions in the vicinity of inhabited areas are a particular advantage.

Lille Waste

1. Introduction

In Lille, France, a pioneering project was launched in 1999 to promote the short-range transport of waste by water. At the time, the city was faced with a pressing problem: The closure of several waste incineration plants due to excessive dioxin emissions forced officials to look for alternative disposal methods. As a solution, the transport of waste by water was introduced. By creating an infrastructure that enabled the transport of waste by water, the city of Lille was not only able to overcome the challenges of waste disposal, but also achieve environmental and economic benefits. Shifting waste transport to the waterways made it possible to reduce the burden of truck traffic on the roads, which in turn led to a reduction in CO2 emissions and noise pollution.

Image of the service

Barge loaded with waste in containers (source: Port of Lille)

Key Facts			
Name of service	Waste transport	Crew	2
Operator	Veolia	Automation	No
Market Segment	Waste	Port equipment	Reachstacker/crane
Region	Ports de Lille	Last Mile Transport	No
Status	Operational	Return Flows	Empty
Launch year	1999	Waterway infrastructure (Navigation Conditions)	3 Locks. Lowest bridge 4,35 metres
Barge Capacity	30-40 containers	Service frequency	Daily
Fleet Size	-	Transport volume	approx. 220.000 t. p.a. since 2007
Ship Length	-	Societal benefits (e.g. mitigated emission)	1,775 tonnes of CO2 avoided p.a.: 20,000 less truck rotations on the roads of the Lille Metropolis
Draught	There is no relevant limitation in draught.	Supportive regulatory framework	No

Key Facts			
Propulsion	Diesel	Financial support	No
Equipment	Open containers		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**

Lille was the first city in France in 1999 to promote the transfer of waste transport to waterways. This service was set up to temporarily replace the waste utilisation of incinerators that had to be closed due to excessive dioxin emissions. Afterwards, the service remained in operation due to a clear need. This regulation therefore favoured transport by water. No specific administrative requirements applied for the launch of waterborne operation. In addition, cooperation was initiated between key stakeholders such as the Port of Lille, VNF and MEL, which served as the basis for the project.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

In 1999, the waste incineration plants in Lille were still disposing of 1,300 tonnes of household waste per day. Three of these incinerators had to be shut down due to excessive dioxin levels. With the closure of these plants, these quantities of waste had to be disposed of by other means. The waterway was used as an interim solution. The consequence of this experience is that it convinced the municipal community to trust the transport of large quantities of waste by water. In the new organisation, the treatment plants were located along the canal in port areas in order to be able to use environmentally friendly means of transport. In 2007, 2 plants were put into operation. Since then, more than 220,000 tonnes were transported per year by waterway. In 2003, the ports of Lille introduced a similar system for used glass, which is recycled in production of new glass.

Criteria	Evaluation
Infrastructure	**Good**

Waste is transported in the Lille region between Loos-Sequedin and Halluin 2 on the border with Belgium on the waterways over a distance of approx. 30 kilometres. The ship passes through 3 locks on the route. A limitation is the maximum bridge clearance of 4.35 metres. However, these conditions allow the transport of open containers (one layer) in which waste is stored. The Organic Valorisation Centre located in the port of Loos-Sequedin is equipped with a terminal and a gantry for loading and unloading of containers. A container terminal with a surface area of one hectare and a 130-metre-long quay was built in the port of Halluin 2. This terminal is Halluin's transhipment point for the transport of containers of waste for Halluin's Energy Recovery Centre. Note that these cargo flows, which originally touched the Halluin 1 port

Criteria	Evaluation
Infrastructure	**Good**
terminal, were moved to Halluin 2 to reduce last mile truck distances. In addition to cranes, reach stackers are also used for loading and unloading.	

Criteria	Evaluation
Vessel	**Good**
With the existing waterway infrastructure and the corresponding navigation conditions, it is possible to use barges loaded with a single-layer of containers. Alternating vessels are used. Generally, a capacity of 30-40 containers per barge is sufficient. They are carried in a single-layer of containers corresponding to the open-top containers tailored for the waste transport. This volume can be carried by standard barges (110 m length). The operation with large capacity strengthens the efficiency of the service.	

Criteria	Evaluation
Logistics/Coordination	**Very Good**
One particular aspect that makes this practice case and the logistics concept behind it successful is the special logistical customisation to enable the conditions for efficient waterborne logistics. Following the decommissioning of the old waste incineration plants, two new recycling plants are located at the waterway. This saves additional distances for the waterborne transport and mitigates last mile truck operation. In the port of Loos-Sequedin, the Organic Valorisation Centre recycles organic waste from the Lille metropolis to produce gas (used by Transpole to power its fleet of buses) and compost (for agriculture). The new site Halluin 2 is directly connected to the ring road that leads to the Halluin's Energy Recovery Centre. This further strengthens the logistic chain and reduces traffic as well as noise annoyance to residents of Halluin.	

Criteria	Evaluation
Competitive position	**Good**
In Lille, the IWT short-range service is well established and competitive. On the one hand, the waterway can unfold various advantages by reducing truck traffic on the road and thus reducing CO2 emissions and noise. In 2019, this river transport avoided the release of 1,775 tonnes of CO2 and removed nearly 20,000 trucks from the roads of the Lille Metropolis. Among other things, the large-scale transport of large quantities of goods shows the possibility of developing economies of scale that make waterborne transport competitive over short distances. The limited need for last mile operation reduces truck operation and makes the service particularly cost-efficient.	

Criteria	Evaluation
Business model	**Good**

The good practice case from Lille shows a viable business model with CO2 savings, noise pollution prevention and substantial reduction of truck transport. The European Metropolis of Lille organizes collection and entrusts a private company with the collection of household waste, through a public tender (currently with ESTERRA, a subsidiary of Veolia). Household and similar waste are collected from 578,000 inhabitants spread across the 34 municipalities in the Lille region – making it the largest waste collection area in France. The company does so in a tailored and innovative way, responding well to the challenges of the Lille Metropole waste master plan. The Lille Metropole committed to this plan in 1992 in a sustainable development approach, which made them a pioneer at the time and still a good reference nowadays. The sustainable development of waste disposal contributes to the feasibility of this short-range IWT business case.

4. Conclusion

Logistics operators at Ports of Lille load and unload dozens of containers transporting waste every day to Loos-Sequedin and the Halluin terminal. For many years, household waste and organic waste from the Lille Metropolis have been transported in containers by water. And it was in Lille that this environmentally exemplary transport was put into practice for the first time in France in 1999. A tailored logistic concept with locations for waste disposal near the river and limited last mile distances contributes to the feasibility of the service. Moreover, commitment from public stakeholders is an important factor.

The presence of a navigable waterway constitutes a prerequisite for the establishment of such services but, in the towns served, the use of river transport can reduce the environmental impact of waste treatment. This mode of transport saves CO2, avoids noise pollution and gets a significant number of trucks off the road and is therefore showcasing the potential of short-range IWT services.

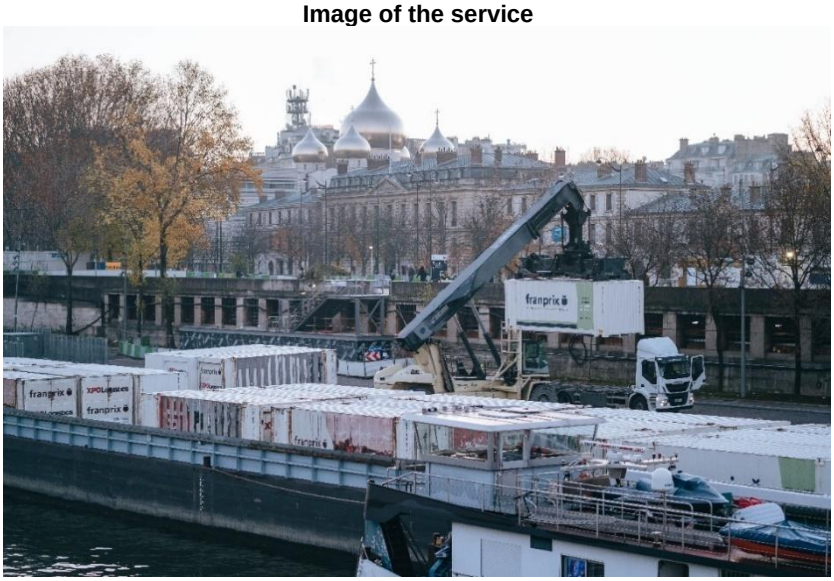
3.3.3 Good Practice Cases for urban and short-Range IWT Services for Retail

Retail Paris

1. Introduction

As one of the major European metropolises, Paris has high logistics requirements. With 3,878 inhabitants per square kilometre, Paris is the most densely populated metropolis on the European mainland. This poses major challenges for road transport and restricts the reliability and flexibility of goods transport by road with an increase in e-commerce business. This is why the City of Paris, the Ile de France, VNF and HAROPA are working together to enable stakeholders to transfer their goods traffic to the waterways. This not only applies to the transport of building materials, such as the construction of the Olympic Village, the reconstruction of Notre Dame or the construction of the Grand Paris Express, but also to the transport of retail products. Two good practice examples from the retail sector are waterborne transport services on behalf of Ikea and Franprix in Paris. These examples have been successful in shifting retail deliveries to the waterway. There were various success factors in the development of these cases, such as the collaboration with major clients and the coordination of stakeholders inside and outside the logistics pipeline. One important stakeholder is the city of Paris, who offers important infrastructure with many historic quays in the city centre such as at the port of Bercy, as well as HAROPA, who offered port locations such as Gennevilliers and Bonneuil-sur-Marne.

Image of the service



Cargo Handling of XPO Franprix at La Bourdonnais (Source: XPO Franprix)

Key Facts			
Name of service	Retail Paris	Crew	1-3
Operator	Sogestran and Box2Home for Ikea, owner-operators/Paris Terminal Safor Franprix	Automation	None
Market Segment	Retail	Port equipment	Reachstackers
Region	France (excl Rhine)	Last Mile Transport	E-Trucks/ Trucks
Status	Operational	Return Flows	Empty Containers
Launch year	2012 (Franprix), 2021 (Ikea)	Waterway infrastructure (Navigation Conditions)	Occasionally high-water levels/floodings

Key Facts			
Barge Capacity	2000 t (FP) and 1200 t (Ikea)	Service frequency	5 days per week (FP), 7 days per Week (Ikea)
Fleet Size	1 per case	Transport volume	Franprix 100.000 p.a.
Ship Length	70 x 8 meters (Ikea, Alpha 01)	Societal benefits (e.g. mitigated emission)	Saving 750,000 truck kilometres p.a. together
Draught	No relevant limits on draught	Supportive regulatory framework	Restrictions for road truck transport
Propulsion	Electric	Financial support	Financial support from public stakeholders
Equipment	On-board crane for Ikea		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Average**

No additional authorisations from the waterway authorities were required for the approval of the vessels used in these projects that could not also be applied to other vessels. However, challenges exist in the development of transshipment sites and storage areas for two reasons. The first are competing interests and the second is a general lack of sites for development in urban areas. Competing interests exist in different directions.

On the one hand, a cultural interest in the preservation of historic quays in the city centre of Paris competes with the development of transshipment points, which makes infrastructure development more difficult due to structural adaptations because of existing monument protection guidelines. In addition, the tourist use and occupancy of the quays and moorings competes with logistical use, which restricts utilisation times for transshipments in the inner city for example. The diverging interests of various stakeholders make the involvement of the City of Paris and public support particularly valuable.

A second challenge in the development of transshipment sites and storage capacities is the general lack of space, which is common in cities, but is exacerbated by environmental guidelines that aim to limit net land consumption to zero. The development of new areas is therefore ruled out if, in return, existing sealed areas are not re-vegetated to compensate for this. This makes the situation particularly difficult for HAROPA. One solution is the development of compressed vertical storage areas such as the Greendock in Gennevilliers.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

The Franprix case started as an experiment at the beginning of 2012, initially supplying 80 stores. Every day, 450 pallets were loaded into 26 containers, which were then delivered to

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

the city centre. In the meantime, this coverage has increased to 300 shops today. 45 full containers are delivered from the ship to a berth close to the Eiffel tower. These increased delivery volumes up to 100.000 t p.a. and also have a positive effect on the cost per transported tonne and increase the efficiency of the service.

There is also similar potential for the transport of Ikea furniture on the Seine. 70% of Ikea deliveries in the Paris area are handled by waterside transport. 30 % of deliveries have to be transported by truck using express shipping. This means that 69,000 shipments in Paris were handled via the Seine in 2023. This is a booming market. The proportion of online orders for Ikea products has risen from 9% to 25%, which has also increased the number of deliveries. The opening of an additional distribution centre in the port of Limay-Porcheville could also create further potential. Both cases show an increasing demand for retail deliveries on the waterways and are now transporting large volumes.

Criteria	Evaluation
Infrastructure	**Good**

For Franprix, the port of Bonneuil-sur-Marne offers good conditions for loading containers and in the port of Genevilliers this also applies to the loading of containers for Ikea. There are good infrastructural conditions that enable largely trouble-free navigation between Bonneuil-sur-Marne and Gennevilliers. There don't exist relevant draught limitations for the service or other major bottlenecks. Bridges with a superstructure height of 6 metres are passable. This means that ships with a length of 125 metres and a width of 11.50 metres can pass through Paris.

There is no deviation in the navigational conditions for the Marne up to the harbour of Bonneuil-sur-Marne. One challenge exists in the development of transshipment sites, due to administrative and regulative requirements as described before.

Criteria	Evaluation
Vessel	**Very Good**

Each service uses one vessel/convoy. The convoy transporting containers for Franprix consists of a push boat and a multipurpose barge. The push boat is operated by an owner-operator. The ship that is used for Ikea is operated by Sogestran. The ship used for Ikea, the Alpha 01, belongs to Sogestran. In addition to the skipper, it requires additional crew to operate an on-board crane, which facilitates the loading of containers. This is necessary because no major structural measures can be carried out on the historically listed quays in Paris to facilitate loading. For this reason, cranes cannot be placed on land. The vessels are well adapted to the service and navigational conditions in Paris and offer enough cargo capacity of 2000 tonnes for the Franprix convoy and 1200 tonnes for the Alpha 01 to realise economies of scale in transport and thus help keep costs down.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

The Franprix service has an advantageous location, as a Franprix logistics centre is located near the water in the port of Bonneuil-sur-Marne. From there, goods can be shipped first via the Marne and then via the Seine to the port near the Eiffel Tower. This route covers around 17.7 kilometres. The Franprix service uses containers in which goods are transported by water, unloaded with the help of 3 reach stackers in total and then emptied. The last mile operation is carried out with 12 trucks to serve more than 300 Franprix stores.

On the one hand, noise pollution can be caused by the transshipment process, and on the other hand, logistics services compete with tourist services for the occupancy of berths in the city centre. This requires an adjustment for timing. The road transport service for Franprix goes along all day from their warehouse to the port, with a cut-off at 5 o'clock in the afternoon, where the barge starts sailing from the Port Bonnueil sur Marne, where around 45 containers are loaded (maximal capacity 48 boxes). The journey to the city centre takes around 2.5 hours. In the evening, the ship arrives at its destination. The following day at 5 a.m., the barge is offloaded, and the trucks are loaded for the last mile operation. The involved actors in Franprix project are XPO logistics, SCAT, and Terminaux de Seine (a subsidiary of Paris Terminal).
The Ikea service also faces similar challenges, but it is possible to operate a night service in the port of Gennevilliers so that Ikea deliveries reach the end customer in a time window between 5 and 7 a.m. and 7 to 9 a.m., thus ensuring delivery reliability. Various partners are involved in the logistical pipeline. Box2Home is responsible for transport and handling operations in the port of Gennevilliers. Sogestran is responsible for transport and handling operations on the waterway with the Alpha 01. At the city centre, Box2Home is again responsible for the handling operation and Trusk for the last mile operation. This means that various companies are interlinked in the supply chain. Constant and mutual communication is therefore of great importance.
This also shows a close integration with a well-coordinated logistics concept. The Franprix case also shows that experience has been gained and the logistics concept has been optimised over more than 10 years.

Criteria	Evaluation
Competitive position	**Very Good**

At the beginning, the delivery of goods by waterway was more expensive than the truck operation. In the meantime, however, waterborne transport has become more efficient when the advantages of delivery reliability are taken into account. The cost for truck operation on the same route are only 15 % lower. Although transport by ship is more expensive, this applies to almost all cases. Even if operating costs increase as a result of waterborne transport, clients are still willing to pay. The waterborne transport services do not only provide an efficient and stable transport solution but create added value for companies such as regarding the achievement of their environmental goals.

Criteria	Evaluation
Competitive position	**Very Good**

The waterborne transport for Ikea has not been in operation that long as the Franprix service yet. However, there is potential here in the increase in e-commerce of Ikea furniture, which can lead to an increase of transport volumes. Another competitive advantage is clearly the avoidance of greenhouse gas emissions. For example, the waterborne transport of Ikea deliveries emits 5 times less CO2 per ton than road transport.

Therefore, IWT logistics better apply to environmental regulations like the environmental zone of the Paris Greater Area ZFE. Ikea examined the concept of gas trucks to make the transport of goods more environmentally friendly. These did not prevail over ships as they were not suitable due to a lack of suitable parking spaces and congestion and their size. This shows that in environmentally friendly transport, the inland waterway vessel has the greatest advantages.

Criteria	Evaluation
Business model	**Very Good**

Both services have the common feature that IWT operators serves the demand of major clients who have the need for a large transport volume, which helps to achieve a constant capacity utilisation or helps to permanently adjust the cargo capacity of the transport service specifically to the transport demand and thus can be considered as a success factor. This is also applicable to other cases in the retail sector. Transport volumes have increased for Franprix over the course of the service. There is similar potential for Ikea due to the growth in e-commerce. One way to establish services of this type on the market is to find and offer customer-specific advantages of the services that increase the willingness to pay.

In general, this can mean greater reliability, especially when truck traffic is restricted by traffic jams or regulations in urban areas. For Franprix and Ikea, however, there is also a monetary marketing effect if the waterborne transport with containers bearing the company logos attracts the attention of residents as well as positive media coverage especially due to the sustainable and innovative form of transport. An additional example here could be the waterborne transport of luxury goods to the centre of Paris. In this case, the monetary advantage for the client is the greater security against theft during transport on the waterway. When designing a business case, these aspects must be taken into account in order to establish the case on the market and to create a feasible business model.

3. Conclusion

The waterborne transport services implemented in Paris, particularly for Franprix and Ikea, showcase promising success stories with notable benefits and some challenges that provide valuable lessons learnt for future projects or services.

The use of historic quays in the city centre as loading points for last-mile transport and existing ports such as Gennevilliers and Bonneuil sur Marne in the joint planning of the participating stakeholders like HAROPA promotes the success of subsequent transport solutions in urban areas. Adaptable logistics concepts, including night operations and well-coordinated supply chains involving multiple partners, ensured reliable and timely deliveries to the city centre, enhancing service efficiency. Significant reduction in CO2 emissions compared to road transport, along with compliance with

regulatory environmental restrictions, positioned the waterborne transport services as environmentally friendly alternatives, appealing to both businesses and regulators.

Constraints such as limited space, time restrictions for loading, and protection of historical monuments in the city centre including historical quays posed challenges for infrastructure development and operational logistics, requiring innovative solutions to overcome. Administrative requirements related to environmental protection and land consumption necessitated careful planning. While the services demonstrated success in their current operations, further expansion and replication of similar initiatives may require addressing evolving market demands, particularly in response to changing consumer behaviour in e-commerce.

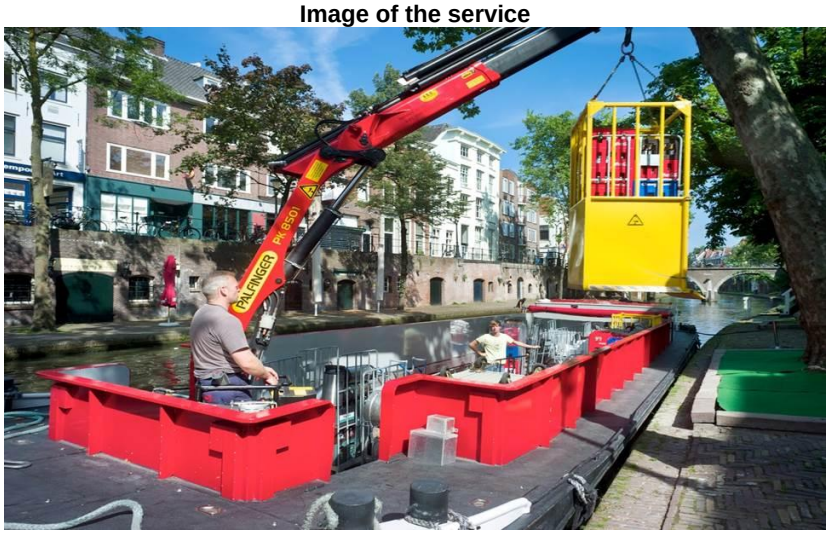
The demonstrated success of the Franprix and the Ikea services underscores the scalability of waterborne transport solutions, with potential for replication in other urban areas, which could unlock further economies of scale. Ongoing innovation and optimization of logistics concepts, including cargo handling and vessel design, will be essential to address emerging challenges and to maintain competitiveness. Emphasizing customer-specific advantages, such as reliability, environmental sustainability, and brand visibility, will be key to driving market adoption and ensuring the long-term viability of waterborne transport services.

Beerboat

1. *Introduction*

The Beerboat in Utrecht is a service provided by the port of Utrecht in collaboration with four breweries like Heineken und Bavaria and six different wholesale and catering companies, which use the Beerboat to transport drinks to local restaurants and bars. There is a close cooperation between the harbour and the clients of the Beerboat, as the service fills an important gap in the inner-city transport. The service was launched in 1996. The Beerboat was electrified in 2010 and a second hybrid ship was purchased in 2012. Due to high demand a third Beerboat was put to tender. This not only shows that the service is well established, but also that there is an increasing demand for suitable and clean transport solutions.

Image of the service



Beerboat in Utrecht (Source: Port of Utrecht)

Key Facts			
Name of service	Beerboat	Crew	1 + 1 staff member of clients
Operator	Port of Utrecht (owned by the City of Utrecht)	Automation	No Automation
Market Segment	Retail	Port equipment	No special port equipment needed
Region	Rhine (Utrecht)	Last Mile Transport	No last mile operation needed
Status	Operational	Return Flows	Packaging waste and empty barrels
Launch year	1996	Waterway infrastructure (Navigation Conditions)	Narrow waterways and low bridges
Barge Capacity	18 t (40-48 roll containers)	Service frequency	5-6 times per week
Fleet Size	2 Beerboats (+1 in tender)	Transport volume	5-6 days per week, with up to 2 trips per day (ca. 12000 t p.a.)
Ship Length	18,8 m (Width 4,26 m)	Societal benefits (e.g. mitigated emission)	17 t of C02 savings per year
Draught	Ca. 1 m	Supportive regulatory framework	-

Key Facts			
Propulsion	400-V AC electric motor of 55 kW	Financial support	Subsidies in the 90s for ship acquisition
Equipment	Hydraulic onboard crane, 480 Volt battery		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**

Because of the navigational limitations due to low bridges and other bottlenecks, there is an extra regulatory framework for waterway navigation within the inner-city limiting height and size of vessels, which are allowed to drive there. Those regulations apply to everyone and the responsible authority for those regulations is the port of Utrecht itself. This also includes speed limits on inner-city waterways. Disturbances can be a problem for the company. The Beerboat leaves for the city at around 7 a.m. to make deliveries. This can cause noise annoyance. The daytime journey could also disturb restaurant visitors. The advantage of the Beerboat, however, is the hybrid electric drive, which means no engine noise. Only the loading process can cause a little noise.

Criteria	Evaluation
Cargo/passenger flows	**Good**

The Beerboat impresses with steadily growing demand and the utilisation of existing capacities. At present, two Beerboats are fully utilised at peak times, with the older Beerboat originally planned as a reserve. This makes it necessary to purchase a third vessel in order to scale the service to the existing demand. It is estimated that the purchase cost of the third Beerboat will be €300-400 thousand as it will need to be fully electric. So, the service is easily scalable by the number of boats, limited by their cost. As a conservative estimate, the annual transport volume of both ships together amounts to approx. 12,000 tonnes per year with a capacity utilisation of 90% and two trips per workday in summer and 1 trip per workday in other seasons.

Criteria	Evaluation
Infrastructure	**Very Good**

Utrecht is a historic city with a special structure. A special feature are the cellars around the canals, which are home to many restaurants. This favours the barge in many ways. Firstly, the cellars in the city centre do not allow traffic of heavy trucks. This means that most of the trucks are not permitted in the city centre. Secondly, the restaurants and bars, which are often located in the cellars, are situated at the level of the waterway often located at the shore. This

Criteria	Evaluation
Infrastructure	**Very Good**

accommodates supply via waterway, however, would require climbing stairs for truck deliveries.

On the other hand, the historic city centre complicates shipping traffic with many low bridges and other bottlenecks. Structural changes to enable loading are often not possible due to existing monument protection or the protection of green spaces. This makes it difficult to find loading locations where service clients can load drinks and other retail products onto the ship. A total of three starting points is used for this initial loading. One of these loading points is located directly at one of the breweries. Apart from a quay wall, however, there are no infrastructural challenges. This reason and the special historical structure favours waterborne transport and offers the best infrastructural requirements.

Criteria	Evaluation
Vessel	**Very Good**

As previously mentioned, the navigational conditions are difficult due to low bridges and other narrow sections. The Beerboat adapts well to these conditions and enables problem-free navigation. Not only the length and width of 18.8 m and 4.26 m are adapted to these conditions, but also the height of the ship with a height of approx. 1.7 m is adapted so that all bridges can be passed.

Drawbridges can also be passed closed, which means that there are no further obstructions to road traffic. The low superstructure of the vessel can also be achieved with an on-board crane, which can be laid flat over the load. Although the use of an on-board crane on such a small ship also leads to a loss of cargo capacity, this is necessary and by no means significant. This is because the on-board crane enables flexible and fast loading and unloading of the Beerboat without the need for further infrastructural adjustments for loading, which would not be possible in the narrow city centre area anyway.

It should also be noted that the Beerboat enables environmentally friendly transport with a hybrid drive system that includes a 480-volt battery, a 55 kW electric motor and a diesel generator. A conversion to full electric operation would cost 75 thousand euros for both vessels. However, with efficient battery utilisation, both vessels can currently operate without the use of the diesel generator. Due to the adaptation to the difficult navigation and loading conditions and the environmentally friendly propulsion system.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

Both the structure and location of the restaurants as already described here and the adaptation of the ship to the existing conditions favour the logistics concept. The on-board crane enables flexible loading and is an important key element here. The last mile operation is also favoured by the location of the restaurants, as bars and restaurants in Utrecht are so close to the water that a last mile operation on land is no longer necessary. The navigation and loading of the ship require one person to steer the ship and the crane. There is also an additional person on board to sort and check deliveries on behalf of the client. This demonstrates the close co-operation between the client and the provider of this service. It

Criteria	Evaluation
Logistics/Coordination	**Very Good**
takes around 1.5 hours to load the ship. The journey from the loading point to the city centre takes around 45 minutes. The restaurants are supplied individually. This means that two trips per day are possible, which can be utilised at peak times. The service shows that it has been able to mature its logistics and find a perfect solution for the special situation.	

Criteria	Evaluation
Competitive position	**Very Good**
The city of Utrecht has ambitious environmental goals. For example, city centre traffic is to be electrified by 2025. This includes both roads and waterways. As the existing Beerboats are already hybrid electric, these requirements can be met. A third ship, which is currently being tendered, will be fully electric. The Beerboat offers a specialised solution, whereby the type of vessel and the logistics concept are specially adapted to the existing infrastructure, thus providing a targeted solution for Utrecht. That is why this service is essential for efficient supply of bars and restaurants etc. in the historic city. As the Beerboat is able to outperform the truck operation this example is showcasing special advantageous conditions.	

Criteria	Evaluation
Business model	**Very Good**
The Port of Utrecht is the provider of the Beerboat service. In addition to the Beerboat, the harbour also operates the Ecoboat, which provides the removal of waste or the recovery of bicycles from the canals, for example. This shows that there is also potential in other market segments. The harbour operates a total of 7 boats. The total acquisition costs of all vessels amounted to €4.5 million. Of this, €500,000 was covered by subsidies. The purchase of the first ship to launch the service had been subsidised by the city and the European Commission, too. The purchase of the first Beerboat in 1996 required an investment of around €200,000. Today, the service is covered by the delivery fees paid by the clients. Clients include breweries and catering companies. Their customers are bars and restaurants in Utrecht. Thus, a cost-efficient service can be achieved. The service has been in operation for a long time, which also proves a sustainable business case.	

3. Conclusion

The Beerboat is convincing in its concept and demonstrates a sustainable and independent operation. The adaptation of the ship to the conditions on site has been very successful, the implementation of the logistics concept is successful, the Beerboat utilises its advantages in intermodal competition and can achieve cost efficiency. There are several success factors, as the close stakeholder cooperation including the port of Utrecht and major costumers of the services. The feasibility and efficiency is linked to the special structure of the city and the location of bars and restaurants. These are located close to the water and often in cellars, which are easier to reach from the water than from a truck. At the same time, due to the historical structure and the basement, there

are weight restrictions for road vehicles, which makes the Beerboat essential. The Beerboat thus finds a market niche that it adapts to.

However, this also means a limitation in the replicability of the case for other cities. Cities that differ in their structure make the implementation of such a concept more difficult, especially if restaurants are either located distant to the waterway or if there are less stringent truck operation limitations. Nevertheless, there are many cities in Holland, Belgium and even France that are trialling similar concepts. In Lyon, for example, Blue Line Logistics is to offer deliveries to restaurants using a ship with an on-board crane. This shows the potential that lies here. The Beerboat also shows how important it is to adapt the service to local conditions and that this adaptation can lead to successful business case.

3.3.4 Good Practice Cases for urban and short-Range IWT Services for Parcels

DHL Berlin / Amsterdam

1. Introduction

As one of the major players in the distribution of parcels, DHL is involved in various projects in the provision of sustainable logistics, as the electrification of distribution vehicles or the development of parcel delivery using waterways. Two major projects in Europe that can be mentioned here is the Solar Boat in Berlin and the Hollands Glorie in Amsterdam.

The DHL Solar Boat in Berlin with electric engine powered by solar modules has been in operation since October 2022, where it transports parcels on the Havel and Spree rivers and delivers them to parcel stations located at the riverside. The commitment of the Port of Berlin (BEHALA) and the Berlin Senate Administration facilitated the establishment of this IWT service.

The establishment of waterborne parcel delivery in Amsterdam dates to 1997. From October 1997 DHL rented a ship to serve as a parcel boat in Amsterdam's canals. After 20 years, the vessel was replaced by an electric version. Hollands Glorie acts as a sailing distribution point for bicycle deliverers to perform the last leg of delivery. The service has been in operation for more than two decades and demonstrates the potential and feasibility of IWT parcel services. Unfortunately, Hollands Glorie was discontinued.

Image of the service

The DHL solar boat in Berlin (Source: DHL)

Key Facts			
Name of service	DHL Berlin / Amsterdam	Crew	1
Operator	Solarwaterworld / Lovers	Automation	No
Market Segment	Parcels	Port equipment	Solar powered parcel stations, cranes and roll-off container
Region	East-West (Berlin)/ Rhine (Amsterdam)	Last Mile Transport	Cargo bikes

Key Facts			
Status	Operational	Return Flows	-
Launch year	Berlin: 2022 Amsterdam: 1997-2018	Waterway infrastructure (Navigation Conditions)	Havel and Spree in Berlin, Amsterdam canal system
Barge Capacity	Berlin: 350 parcels	Service frequency	Daily
Fleet Size	1 for each case	Transport volume	Between October 2022 and End of August 2023 50.000 parcels in Berlin
Ship Length	Berlin: 10,50 m Amsterdam: 16.35 m	Societal benefits (e.g. mitigated emission)	Reduction of 150000 car-kilometres p.a. in Amsterdam
Draught	No relevant limitations	Supportive regulatory framework	Cooperation contract with city administration in Berlin, Implementation Agenda Zero Emission Mobility Amsterdam 2023-2026
Propulsion	Berlin: Electric engine powered by solar modules Amsterdam: Engine TDI 2.5-120 Power 120hp Propulsion Propeller shaft	Financial support	No
Equipment	Berlin: Battery		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**

In Berlin, the cooperation with the city administration underlines the commitment to establish the waterborne parcel delivery service. The solar boat operation and the installation of solar powered parcel stations had to be approved by authorities.

The concept of waterborne parcel delivery fits well with the Amsterdam municipality's efforts to achieve emission-free transport in the city (Implementation Agenda Zero Emission Mobility Amsterdam 2023-2026). According to these plans, there will be zero-emission zones for taxis, delivery vans, trucks, scooters, and motorboats from 2025. This is intended to promote the registration of new environmentally friendly vehicles, but also incentivises a modal shift of traffic to waterways. The administration aims to find more companies that deliver parcels via boat in the city centre. This should prevent congestion on land. The problem with transporting cargo by water is that most canal walls are too high and the laying of jetties is banned almost everywhere by the municipality. So, the number of points where transhipment is possible is limited.

Criteria	Evaluation
Cargo/passenger flows	**Good**

The solar boat currently delivers 350 parcels a day on one route from Spandau to the city centre of Berlin. Further delivery routes via Köpenick and the “Osthafen” harbour are planned to scale up the service. There is large potential considering that DHL delivers 250.000 per day within the Berlin metropolis. The solar boat operation could be further extended by adding new routes and increasing the frequency of deliveries. To further strengthen the potential, it would also be possible to install additional parcel stations along the waterways. It is expected that the number of parcels delivered by waterway will increase substantially compared with the transport volume during the test phase since autumn 2022. A cooperation agreement was signed with the city administration until 2029. Additional routes and stops will be launched.

Criteria	Evaluation
Infrastructure	**Very Good**

Berlin has a dense waterway infrastructure network. This favours urban accessibility by waterway. The solar boat starts in the southern harbour of Spandau and travels 10 km to the Westhafen, the largest port in Berlin. From there, the solar boat serves various stops to discharge parcels. At the stops a landing stage has been implemented and parcel stations close to the water are installed. One point worth mentioning here is the challenging development of transshipment points. Available space in the city centre is rare and makes development difficult. This requires integrated cooperation between the various private and public stakeholders such as DHL, BEHALA and the Berlin Administration.

The development of new riverside structures along the Spree demonstrates the commitment of the Berlin administration. To strengthen this cooperation, DHL will sign an agreement for five years to further cooperate with the Berlin Senate until February 2029, which will then make it possible to set up around ten solar-powered packing stations along new routes. Also, the cooperation between BEHALA at the Westhafen port and the port in Spandau favours parcel transport. In both cases, there is a dense waterway network whose potential is being utilised.

There were only little infrastructural adaptions required for the parcel waterway transportation in Amsterdam, as a dense and well-developed waterway infrastructure is available. However, mooring points are scarce, due too high waterway traffic with a lot of touristic ships and house boats. Sometimes they are even subject to litigation. Also, there is the need for mooring points that can be used as charging points for the electric vessel's batteries. Since there is nighttime mooring, batteries can be charged during these hours.

Criteria	Evaluation
Vessel	**Very Good**

In Berlin, DHL and Solarwaterworld AG jointly developed an electrically powered solar-powered ship that is capable of loading parcels. The ship is 10.5 metres long and 2.5 metres wide. Solar modules are attached to the roof, which ensure that the ship can be operated completely emission-

Criteria	Evaluation
Vessel	Very Good

free. When the sun is shining, the solar panels are sufficient to operate the boat. In cloudy weather, the battery can supply the boat with sufficient energy for 6-8 hours. The ship has a propulsion power of 5 kW. This is enough to accelerate up to 12 km/h. At the stern there is a hatch in the roof that can be opened so that a crane or other equipment can be used to load and unload roll containers containing the parcels. This means that 350 packages can be loaded onto the solar boat. With the extension of services, a second solar boat will join the fleet.

For the management and operation of the parcel boat in Amsterdam the Hollands Glorie, DHL Express works closely with shipping company Lovers, from which the vessel is also leased. It involved a vessel which had been used as a tour boat before. It was precisely designed for sailing through Amsterdam's canals. Size of vessel is limited due to Amsterdam canals and bridges. The operation started with conventional propulsion and was adapted to electric operation. As a result, the concept has grown with the times, making it emission-free. Both ships in Berlin and in Amsterdam are customised solutions for the challenges in navigation and logistics as well as adapted to sustainable operations.

Criteria	Evaluation
Logistics/Coordination	Good

In Berlin, the existing distribution route runs via the port of Spandau in South Berlin. The ship then travels 19 km via the Westhafen to stops in the city centre for discharging parcels. Here last mile distribution is carried out by cargo bikes. A second route is also being planned from the Altstadt Köpenick jetty via several stops with solar-powered DHL packing stations to the Osthafen harbour, a distance of approx. 11 km. Cargo bikes are used for last mile transport. Moreover, parcel stations close to the water are used in Berlin, which saves last mile distribution at these locations. The combination of cargo bike and barge is a dynamic concept that can serve to a large area coverage in Berlin due to dense network of existing waterways.

The logistics concept in Amsterdam with the Hollands Glorie offered great advantages by making use of the benefits that transport by water has to offer. At night, the boat was moored just outside the city at a berth in the Westkom of the Open Havenfront. In the morning, electric delivery trucks bring the first load of parcels from Schiphol Airport. A second truckload follows in the afternoon. The boat then docks at various locations in the city centre, where various bicycle couriers take over the packages. Three DHL express delivery coordinators share the job of shuttling between the delivery jetty outside the city centre and the Koningsplein twice a day.

Criteria	Evaluation
Competitive position	Good

The Berlin case offers advantages through emissions free ship operation. The solar boat fits in well with the DHL fleet portfolio including a large share of electric vehicles. This means that a CO2-efficient last mile operation can also be organised, which strengthens the waterborne logistics concept. Despite the strong cost competition in parcel delivery, the cooperation shows the commitment by DHL and stakeholders to mitigate truck operation and emissions through a modal shift of parcel delivery to waterway and use of zero emission solar boats. A challenge is

Criteria	Evaluation
Competitive position	**Good**
that customers are still used to fast delivery of online orders within 24-72 hours which emphasises the competition in the parcel delivery sector. It is estimated that transporting parcels by water takes 10 hours longer than by road within the complete transport supply chain, showing logistical challenges. Nevertheless, there are also advantages in intermodal competition. The growth of the e-commerce sector and the accompanying demand for parcel deliveries requires additional capacities which are hardly available on congested urban roads. The availability of car parking spaces can also make parcel delivery more difficult. Overall, it is the scope of the project to replace two 40 t trucks with one solar boat in future. Switching to the boat/bike combination allowed DHL to reduce their city centre vehicle fleet for Amsterdam from 10 to 2 at the time the Hollands Glorie was in operation. This amounted to 150,000 km less travelled per year, saving 12,000 litres of diesel per year, avoiding 10 cars every day (reduction of 150,000 car-kilometres).	

Criteria	Evaluation
Business model	**Good**
The development of the concept in Berlin was inspired by the project in Amsterdam, which was in operation for a long time. The Berlin concept benefits from the experiences from Amsterdam and continues to develop the initiated paths. DHL is showing its commitment here in Berlin with a long-term cooperation agreement to develop parcel delivery by waterway including the installation of riverside parcel stations. The cooperation agreement signed by DHL after successful test operation since 2022 confirms the feasibility of the business model. The commitment of key stakeholders will facilitate the service development and contribute to long-term establishment of waterborne parcel delivery in Berlin. The service in Amsterdam was operated by DHL, which leased the vessel from shipping company Lovers (operational lease). The service has since been discontinued. It is known, however, that this happened many years (more than 20) after the service started. This suggests that the service must have operated at least around the break-even point for many years. Large losses should have caused the service to stop after only a few years.	

3. Conclusion

The good practice cases of DHL's inland waterway projects for parcel delivery, such as the Solar Boat in Berlin and Hollands Glorie in Amsterdam, offer important insights into the future of urban parcel logistics and demonstrate the potential of waterways as a sustainable means of transport. The success of these projects is based on various factors. Close co-operation between companies such as DHL, authorities and other stakeholders has helped to overcome infrastructural and administrative hurdles. The integration of waterways into supply chains not only enables a reduction in CO2 emissions, but also helps to relieve road traffic and tackle traffic problems in urban areas. The use of zero emission ships such as the solar boat further reduces the environmental impact.

Nevertheless, these projects also face challenges. The limited number of landing stages and the difficulty of developing transshipment points in urban areas can affect the efficiency of barge transport. The organisation of last mile delivery requires smart concepts. The installation of riverside parcel stations is a promising solution. In addition, the increasing demand for fast deliveries in the e-commerce sector requires innovative solutions to ensure the competitiveness of inland waterway transport. Logistical challenges such as longer transit times compared to road transport require continuous optimisation of operational processes.

Despite these challenges, DHL's inland waterway projects offer considerable potential for the future of urban logistics. Further success can be achieved through the further development of infrastructure, the optimisation of operational processes and the promotion of multi-stakeholder partnerships. However, the rollout of such projects in other urban areas requires careful planning and coordination to consider the specific requirements and challenges of each location. Ultimately, the success of these initiatives will depend largely on the ability to develop innovative solutions that ensure sustainable and efficient urban logistics.

A-Swarm

1. Introduction

The A-Swarm project in Berlin is an attempt to utilise the dense waterway network in and around Berlin for urban logistics in the German capital. For this reason, the concept of an autonomous ship is being developed as part of this project. This concept includes smaller ship units, which can be linked together to form larger convoys. Within the city these convoys split up, to deliver individual decentralized hubs. To provide a flexible and emissions free transport, the barges use an electric propulsion system, which can rotate to enable route adjustments.

The research project is intended to provide the basis for finding the technological answer to gain flexible and efficient concepts for logistical solutions on urban waterways. Many partners are involved in this project. In addition to the operators of the Berlin harbours (BEHALA), the Technical University of Berlin, the University of Rostock, DHL and others are also involved. A-Swarm already achieved some results in its first research phase. A second research phase is planned. For DHL, the concept shows potential for the waterborne transport of parcels.

Image of the service

A-Swarm Prototypes in Berlin Westport/BEHALA (Source: BEHALA)

Key Facts			
Name of service	A-Swarm	Crew	0
Operator (Research and Development Consortium)	BEHALA, SVA GmbH, TU-Berlin, University of Rostock, DHL Technologies AG Munich, Veinland GmbH Neuseddin and PTJ	Automation	At the moment partial automation with remote control (3), in the future: fully automated operation (5).
Market Segment	Parcels	Port equipment	Depending on the height of quays cranes might be necessary.
Region	East-West (Berlin)	Last Mile Transport	Cargo Bikes

Key Facts			
Status	Pilot/Living Lab	Return Flows	Empty containers, in future return packages
Launch year	2019	Waterway infrastructure (Navigation Conditions)	Height of quay walls might be difficult for transshipment.
Barge Capacity	4-8 Cargo Bike Containers	Service frequency	No operational service now, in future daily service possible
Fleet Size	2 (Additionally the bow and stern parts are being tested in another research project.)	Transport volume	A simulation will be carried out within the DigitalSOW-project.
Ship Length	Now 6m, in future: 14m (Width 6m)	Societal benefits (e.g. mitigated emission)	Saving co2-emissions, street mitigation and work force input
Draught	0.5 – 1 meter	Supportive regulatory framework	-
Propulsion	Electric drive units in the bow and stern of the ship	Financial support	Funded by the Federal Ministry for Economic Affairs and Energy (Maritime Research Strategy 2025 framework)
Equipment	2x Rotatable RIM Drives 5 Kw, Qualisys Motion Capture System magnets on the sides of the ship, sensor units		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Average**
Even if the automation of the IWT brings many advantages, this technology complicates the authorisation process. Due to the complex technological design, there is currently no authorisation from the German waterway authorities (GDWS) for the use on the federal waterways in Berlin. Prototypes have been tested in the private area of BEHALA in Berlin's Westhafen Harbour. This includes two harbour basins, but also short sections of the Western Harbour Canal and the Hohenzollern Canal. There is a need for technology-appropriate regulation by the responsible authorities. An approval is regarded as reasonable considering, as the technology is sufficiently mature for safe test use on federal waterways, as various experiments have shown. A new application was submitted to the GDWS for the new research phase.	

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

The project is currently still in a test phase and no deliveries have been made yet. One subject of the first test phase was besides autonomous navigation the manual loading of bicycle containers to test the concept. One subject of the second test phase will be the testing of parcel deliveries together with DHL at parcel micro-hubs that have been developed for delivery by the solar-boat.

Future routes for the A-swarm could lead deliveries to the Westhafen harbour close to the centre of Berlin, as well other unloading points at the Spree River including central station. DHL estimates that there is a business case for A-Swarm with a daily minimal delivery volume of ca. 2,000 parcels per day. This depends on various factors such as the number of A-Swarm boats, their acquisition costs and also the acquisition costs of cargo bikes. DHL sees one advantage of the A-Swarm concept in its scalability.

Once the development of the A-Swarm vessel has reached the stage where these ships can be produced in series, the capacity of the push convoy can be flexibly adjusted by the number of A-Swarm units used. This means that a high degree of scalability can be achieved. Once research and development are complete, potential demand could exceed 10,000 parcel deliveries per day in the long term.

Criteria	Evaluation
Infrastructure	**Average**

The ideal quay wall structure for transshipment includes a quay wall height at the level of the unloading height. If there is a difference between these two heights, a crane or structural measures can help. Stairs also represent an obstacle. Ramps are required for rolling the bicycle containers. The final infrastructural conditions therefore also depend on the final concept for ship handling and the technical autonomous process of docking, which will be further specified in the second research phase.

The question here will be what infrastructural measures need to be created to enable autonomous waterborne transport. The construction of shoreside micro-hubs is necessary for the last mile concept. A simulation as part of the first research phase showed that a coverage of 50 % of households in Berlin could already be achieved with just 8 micro-hubs. Possible starting points where convoys could be loaded with parcels are the western and southern harbours. The port of Mariendorf with an adjacent DHL distribution centre and a logistics centre of a large retailer could also be considered. The question currently remains open as to whether additional structural measures will be necessary for loading and docking or whether the ship concept will have to be adapted.

Criteria	Evaluation
Vessel	**Very Good**

A-swarm offers several advantages, seamlessly integrating an electric, eco-friendly drive with autonomous control and versatile deployment options, including the innovative use of a convoy concept. Notably, its unique strength lies in the ability to divide and link individual vessels as one convoy using strong magnets. Two magnets are attached to each side of the ship, which can be flexibly switched on and off. Each magnet has a holding capacity of 3 tonnes, allowing the convoy to navigate urban areas in a cohesive formation and enabling decentralized deliveries as soon the convoy enters the delivery area. This ingenious concept significantly enhances the scalability of urban IWT, paving the way for potential future business cases.

It is not yet clear yet, whether the magnets will be sufficient to hold an entire convoy together. Presumably, magnets will be used for positioning and another mechanical holding system will close the convoy in the end. The magnets can also help with positioning when mooring the ship. The concept will be expanded in the second research phase. The DigitalSOW project is also developing bow and stern pieces that can be connected to the small A-Swarm vessels in the same way. The DigitalSOW project also aims to expand the concept for supra-regional inland waterway transport so that the bow and stern sections developed there can be used as propulsion units for barges. This would increase the scalability and flexibility of a market-ready concept. Problems when navigating can be caused by signal interference.

Satellite-dependent signals such as AIS and GPS can be disrupted under bridges, in locks or between tall buildings, for example. Camera systems can be disrupted in darkness or fog. For this reason, the system has technical redundancies such as infrared cameras to minimise this risk. Accurate positioning is only necessary when locking the convoy and docking the ships. Additionally, the vessel also enables a sustainable operation due to electric propulsion.

Criteria	Evaluation
Logistics/Coordination	**Good**

One logistical aspect is the swarming capability of the concept that could benefit efficiency for serving multiple micro-hubs at the same time. One micro-hub concept has already been implemented at Berlin's Westhafen harbour. Pick-up parcel stations could also be supplied by A-Swarm ships. These would offer the advantage that no further last mile transport would be necessary, as consumers would collect their parcels themselves, which would reduce costs. An initial route from Westhafen to the city centre is already in place, with various micro-hubs and pick-up points. The aim is to cover this route with A-Swarm in the future too.

However, there are also challenges, particularly when it comes to unloading, as this must be carried out autonomously and therefore without personnel. The development of a finished logistics concept is also the aim of the second research phase. There is a lot of potential in this development due to the autonomous and swarm-capable logistic concept. However, there are also challenges that still need to be solved e.g. the process of transshipment.

Criteria	Evaluation
Competitive position	**Good**

The A-Swarm concept can strengthen the performance and competitive position; however, this concept still requires technological development and approval as well as would require high setup cost. The implementation of a new concept and technological development are cost drivers, while the upscaling of road delivery capacities is comparatively cheap even if electric vehicles will be used. The operating time and thus the operating costs are also higher for ship transport than for truck transport.

But the automation of inland waterway vessels can reduce labour costs and strengthen efficiency. In addition, the swarming capability of the A-Swarm boats, increases flexibility and scalability. Another advantage is the avoidance of congestion when transporting parcels. Other disadvantages of truck operations are a lack of parking spaces and higher CO2 emissions and particulate matter. All of this offers ideal conditions for testing a business case.

Criteria	Evaluation
Business model	**Good**

The innovative A-Swarm project promotes important research and insights into the automation of inland waterway transport. The project does not yet represent a fully developed business case, as research into the possibilities of these new technologies in this project framework still needs to be further explored. The further development and elaboration of the concept is the aim of the next research phase. In the first research phase of the project the Federal Ministry of Economic Affairs and Climate Action approved a total of 4.2 million euros. DHL is involved in the second research phase.

Additionally, the Inland Ports' Readiness for Automated Inland Navigation (RAIN) research project will also analyse the possibilities for developing business cases for projects such as A-Swarm from the necessary economic perspectives. The RAIN project is funded by the IHATEC project management organisation for innovative port management of the Federal Ministry of Transport and Digital Infrastructure. Regarding the concept of the A-Swarm Project and the DigitalSOW project various business cases are possible based on the current developments. For example, A-Swarm vessels could be used to deliver parcels in the future in the same way as the DHL solar boat is used nowadays.

The potential for a business case exists. Looking at future research results could provide more insight, but the A-Swarm project remains a promising case and the integration of autonomous navigation of inland vessels into a small-scale ship types offers various potentials. The project works on important research for the future technology of autonomous vessels, which could strengthen the potential of urban and short-range IWT services in general.

3. Conclusion

The A-Swarm project is a promising case, as various insights can be gained from the project work to date. The project offers impressive technical experience in the development of an autonomous boat. This technical development is faster than the regulation of waterway authorities. Within the European

framework, adjustments still need to be made to waterway legislation for autonomous transport in order to enable the development from research project to business case. A pioneer in this respect is the Flemish region, whose waterways have been declared a test area by the Flemish waterway authorities. This opens up many development opportunities in research projects such as AVATAR, in which stakeholders such as Seafar are involved.

It is of great importance to continue researching autonomous inland navigation, as there are various open questions not only regarding technical feasibility, which is progressing well, but also regarding economic sustainability. Certainly, autonomous shipping will reduce operating costs. But what infrastructural adjustments need to be made to enable small-scale autonomous freight transport on urban waterways? Where solutions for the autonomous navigation of ships already exist, further insights into the autonomous loading of goods and autonomous docking are needed to estimate the setup costs of the new technology. The A-Swarm project can provide important insights here in the future.

3.3.5 Good Practice Cases for urban and short-Range IWT Services for Mixed Freight Goods

ULS Strasbourg/ Lyon

1. Introduction

Urban Logistics Solution (ULS) is a young company that can convince customers with new approaches. This includes the vertical integration of waterborne transport into the urban supply chain. Founded in Strasbourg, ULS now offers its services in four other cities: Rouen, Mulhouse, Lyon and Paris. ULS operates 7 docks, two of which are in Paris. This demonstrates the potential that the company is striving for to not only be the operator of waterborne transport, but to be able to offer solutions for the entire supply chain, whether in last mile operations, waterway transport or storage services.

Image of the service

Transshipment in Strasbourg (Source: ULS)

Key Facts			
Name of service	Urban Logistics Solutions	Crew	2 per ship (operating barge and landside crane)
Operator	Urban Logistics Solutions	Automation	None
Market Segment	Mixed	Port equipment	Cranes and trollies
Region	Rhine (Strasbourg, Mulhouse), France (Excl. Rhine, Lyon, Paris, Rouen)	Last Mile Transport	Cargo bikes
Status	Operational	Return Flows	Cardboards and packaging waste
Launch year	2020	Waterway infrastructure (Navigation Conditions)	Conditions differ by city

Key Facts			
Barge Capacity	5 – 10 t p. barge (in Strasbourg), in future 200 t. possible	Service frequency	6 days p. week and 3-4 times p. day
Fleet Size	1 push boat with 1 barge p. dock (7 docks in 5 cities)	Transport volume	15-20 t p. day, potential for 200 t p. day
Ship Length	Differs p. barge used in different cities	Societal benefits (e.g. mitigated emission)	Saves Co2 Emissions, reducing mitigation
Draught	Differ p. city Strasbourg ca. 2 m, Lyon ca. 3 m	Supportive regulatory framework	Truck restrictions
Propulsion	Gas2Liquid in future hybrid propulsion	Financial support	Subsidies for setup costs
Equipment	Specialized containers, in future on-board-cranes		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**

As usual, there are administrative requirements for traffic on the waterway to ensure safe transport. In particular, the ULS Service has adapted to the administrative requirements for managing ships and the necessary deployment of personnel to enable flexible and efficient use of the labour input. This means that the same navigational skills are not required on the short route as in conventional inland waterway transport, which saves time in staff training. In addition, skippers are also trained to operate the crane, which saves additional labour costs.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

ULS is planning to scale up the existing logistics concept, which can be explained using the example of the service in Strasbourg. Here, a push boat operates with a smaller barge with a cargo capacity of approx. 5-10 tonnes. Nevertheless, a large transport volume can be achieved through a high number of rotations, during which the return journey can also be used for the removal of packaging waste. There are 3-4 trips per day, starting at 10 a.m. with another regular trip at 12 p.m. and further possible trips in the afternoon. This results in a transport volume of 15-20 tonnes per day, 6 days a week.

However, there is potential for scaling up due to growing demand. This is why ULS is developing specially adapted barges that can be plugged together like a modular system in order to adapt specifically to the transport requirements of the individual city. Individual barges can be transported from city to city by truck, which further increases flexibility. Further investment is still required for implementation, but ULS has proven the feasibility of the transport system to date, thus enabling scaling in the future. Due to the flexible scalability of the concept, this case is showcasing potential and scalability. Future developments have to be taken into account.

Criteria	Evaluation
Infrastructure	**Very Good**

The example in Strasbourg shows a good existing infrastructure. In the Rhine harbour on the outskirts of the city, ULS has its own storage and transshipment site of 2.5 hectares. The storage capacity is to be expanded in future due to increasing demand. A movable crane is used for transshipment. In the city centre, ULS has a micro hub, also equipped with a crane. The route takes half an hour between both locations. These are ideal conditions for the existing business.

In future, the service is to be scaled up further and also made more flexible. An important step in this direction is the planned acquisition of on-board cranes, which are planned for the new ship type. This will help to expand the service to cities that do not offer the same infrastructure as Strasbourg. However, municipal support can also promote the development of relevant storage and transshipment sites and help to find suitable terminals for city centre distribution. Urban navigation conditions are often challenging due to, for example, low bridge heights, shallow waters or other bottlenecks like locks. This is why push boats and barges used by ULS are adapted to these navigational conditions. In all cities, the service adapts to the conditions. The infrastructural conditions and the adaptation to these conditions offer potential.

Criteria	Evaluation
Vessel	**Good**

Regarding the example in Strasbourg, ULS has its own push boat in Strasbourg. Research was done in advance to find out which push boat would be best suited to the navigation conditions in Strasbourg. The vessel was developed in Portugal. The barge that ULS uses in Strasbourg was rented from VNF and has an approximate cargo capacity of 5 to 10 tonnes.

The plan is to develop a modular type of vessel that will allow barge convoys to be flexibly adapted to local conditions and provide a global, replicable service throughout Europe. The plan is that each ship module can be transported by truck. Later, the modules will be connected to each other and can be equipped with an on-board crane. The capacity of such barges should reach up to 120 tonnes and help to scale the service. The plans show great potential and future developments need to be considered.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

Two crucial aspects of the ULS logistics concept are vertical integration within the supply chain and the customisation of the service to the needs of different customer groups with different goods. The first aspect implies that ULS not only offers waterborne urban transport, but also all relevant services of the urban supply chain. This starts with storage and consolidation outside the city. This is followed by loading and transport on the waterway and inner-city distribution using cargo bikes. The production of special containers is also

Criteria	Evaluation
Logistics/Coordination	**Very Good**

integrated into the company to further facilitate transport and enable fast and safe loading. The second aspect is the flexibility offered in the transport service provided. ULS differentiates between 5 groups of goods that play a role in city goods logistics. These include trucks loads of large logistics companies such as GEODIS, postal and parcel deliveries, heavy goods such as drinks for restaurants, waste and packaging waste that can be transported on return journeys and high street business for inner city shops. This allows for more flexible utilisation of transport capacity in the event of fluctuating demand from individual customers and enables the service to be scaled up in the future.

Criteria	Evaluation
Competitive position	**Very Good**

Competing with conventional logistics concepts is a challenge. Trucks are often used to supply inner-city areas, as they are often more flexible and cost-effective over short distances. However, increasing environmental regulation is imposing limits on inner-city truck transport. This is also the case in Strasbourg and Lyon, for example. Since 2018, there has been a restriction on truck traffic in Strasbourg from 10:30 for trucks heavier than 7.5 tonnes in the city centre and from 11:30 for e-trucks heavier than 7.5 tonnes. Within these time windows, there is still a need for goods transport. This is a competitive advantage for the ULS service.

At the same time, with its waterborne urban transport, ULS manages to achieve the same price level as road operation. This shows not only that the integration of IWT into urban logistics can be competitive, but also that the limitation of truck traffic in the city centre does not need be compromised if waterways are available. ULS can offer an environmentally friendly alternative that helps to reduce road traffic. The proportion of the fix costs of transport is around 70 %.

Scaling up the service can open even more potential and reduce marginal costs and therefore increasing the competitive advantage of the waterborne urban supply chain. This requires precise logistical coordination and the development of new modular ship types, which ULS is planning.

Criteria	Evaluation
Business model	**Very Good**

The logistics concept of ULS developed the vertical integration of the urban supply chain with ship and cargo bikes as well as the offer of transport services for a mix of different customers, this opens up a business case within which costs can be reduced and many customers can be addressed, including major key clients such as GEODIS. Partners of this size in every freight group, from parcels to heavy goods, could help to scale the service and logistics concept. ULS is already achieving feasibility at standard market prices without being dependent on public funding. Only initial investments have so far been subsidised with public funds.

However, support from the local administration is still important, e.g. in the search for accessible sites for storage and transshipment. Overall, the ULS business model is showcasing high potential due to its feasibility and the logistical approaches like the vertical

Criteria	Evaluation
Business model	**Very Good**
integration within the logistical supply chain and the flexible handling of different freight groups that could open a large sales market for the logistics service.	

3. Conclusion

ULS started its service in Strasbourg and soon expanded to further cities as a waterborne logistics service provider. This shows the potential that has already been realised. Additional potential has been identified by ULS. Rivers flow through many major cities in Europe and most of the historic city centres are concentrated close to the river and therefore have a high population density. This high population density close to the riverbank increases the potential. According to internal calculations by ULS, there are 40 million inhabitants in Europe within a radius that could be supplied with ULS cargo bikes. The administrative regulation and limitation of truck traffic can act as a catalyst for this potential.

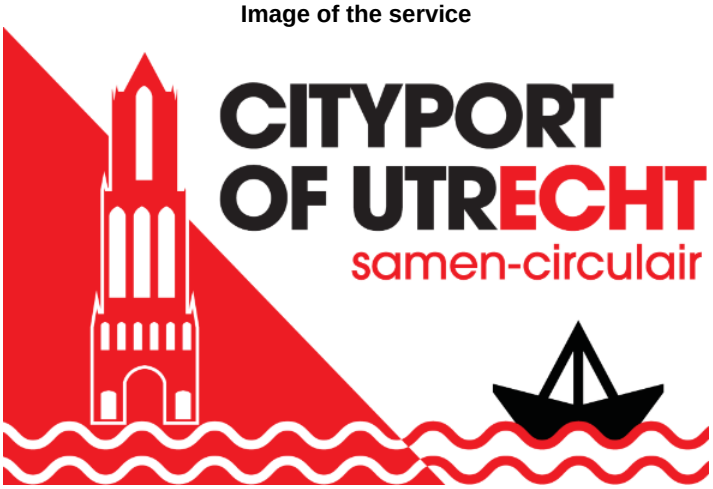
However, an important key finding from this case is that functioning and efficient urban logistics is possible with such truck traffic limits, which could also favour truck limits in the future, as the feasibility can be proven. Cargo bikes and delivery ships form an efficient combination and offer a transport and logistics service that is better adapted to the city centre than truck traffic and can avoid the disadvantages of truck traffic, such as CO2 emissions.

Cityport of Utrecht

1. Introduction

This case is about the logistical service provider Cityport of Utrecht, its mission is to revitalise waterborne transport over the city's old canals. Its main asset is the Liesboschhaven, a small port very close to the inner city but still relatively easy to reach with large trucks (and some smaller barges as well). Here, they offer a white-label hub, i.e. a location where everyone that wants to move goods in and out of the inner city can make use of the facilities to tranship goods from trucks to small barges that can move into the city. In the city, micro-hubs to load and unload barges are offered as well. Although the small barges are a vital part of the logistic operations, they are not part of Cityport per sé but can be operated by all service providers. Thus, Cityport embodies a port service whose clients are IWT operators. In this sense, this case differs from other good practice examples from this list but complements the portfolio in a valuable way and shows a different perspective within the urban supply chain. Now, one of the partners of Cityport is Citybarge, whose small push barges make use of the Liesboschhaven.

Image of the service



Cityport of Utrecht Logo (Source: cityport.nl)

Key Facts			
Name of service	Cityport of Utrecht	Return Flows	Differs per case. Waste is often the return flow.
Operator	Cityport of Utrecht	Waterway infrastructure (Navigation Conditions)	Small-scale. But the port area is reachable by slightly bigger barges as well.
Market Segment	Mixed (inner city logistics, waste, building materials)	Societal benefits (e.g. mitigated emission)	Modal shift from road to water. Decreases pressure on congested inner-city roads.
Region	Rhine (Utrecht)	Supportive regulatory framework	Local governments are supportive.
Status	Operational	Port equipment	Own port facilities to load and unload barges. Some vessels carry cranes to (off-)load cargo in the inner city. Others do not and rely on cranes on the city quays.

Key Facts			
Launch year	2022		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Average**
There is certainly legislation that helps to integrate IWT operation into urban logistics within cases like that. For example, all initiatives to green transport as a whole are seen as a big plus. Furthermore, the province, many municipalities, RWS (fairway manager) are active members of the initiative and support it with policy (and funding). However, within inner city planning ("Ruimtelijke Ordening") in Dutch cities the main and almost only recognised goal is to build housing spaces. Therefore, all open space in a city is a target to build houses and can be hit with regulation that makes it impossible to use it for transport in the future. This makes it hard to obtain transshipment and mooring sites. Furthermore, once housing has been realised, the main thoughts about water are recreational: water near houses is first and foremost meant to look at and for pleasure craft. Cargo transport (bigger or "ugly" vessels) is not wanted or protected. Can be hit with complaints by citizens. Another typically Dutch problem in inner cities is dedicated to bike-lanes (so-called fietslinten). Fietslinten are bike-lanes that are regulated and protected; they cannot be interrupted. In many cities these are so close to the water that they effectively render entire quay walls impossible for (off-)loading cargo.	

Criteria	Evaluation
Cargo/passenger flows	**Good**
There have been many operational movements to and from the hub serving city locations. The hub offers an ideal location to move cargo into the city and tranship it from barge to truck or vice versa. Similar as to the Citybarge concept: Inner cities are in need of many goods to be transported in; many Dutch cities have large building projects going on where large volumes of building materials will be needed over the coming years. Similarly, many shops might be serviced by the concept, and the inflow of goods they need is probably even bigger in volume. However, inner cities also produce a lot of waste (building waste, commercial waste, residential waste) which needs to be disposed of. This can also be moved by Citybarge. All in all, both inflow and outflow of cargo is high in urban environments. Therefore, there is substantial potential for modal shift of urban logistics to the waterway by implementing the Cityport concept.	

Criteria	Evaluation
Infrastructure	**Very Good**
The Cityport operator owns its own key infrastructure, which is the hub with transshipment facilities between trucks and small barges. They can also offer pontoons as micro-hubs in the	

Criteria	Evaluation
Infrastructure	**Very Good**

inner city. The installation of small pontoons gives the opportunity to establish locations for loading and unloading of cargo rather flexible along the city waterways.

The company is only dependent on public waterway infrastructure (fairways, bridges, locks). The accessibility of the largest inner-city port location Liesboschhaven which acts as hub in the CItyport concept serving the historic city with small boats is not accessible by standard vessels used on the Amsterdam-Rhine Canal serving the inland port of Utrecht (Lage Weide).

In the historic urban centre of Utrecht, the waterways are narrow, and it is more difficult to navigate there. However, the infrastructure provided by the Cityport enables small boats to transport goods from the city centre and thus offers urban water logistics that has adapted to the conditions. Within the inner cities, many locks are old. This is not that large of a problem, but modern equipment would work faster. However, especially new bridges pose a problem. New building practices favour low bridges because this makes it easier to bike over them. However, in that case many bridges are built too low for the used vessels. This adds the need to wait for them to be opened.

Criteria	Evaluation
Vessel	**Good**

As this is a port service and not a pure IWT service, the Cityport does not operate its own vessels. However, an assessment can be made of the vessel types that use the Cityport for themselves. There are complementarily a couple of vessel types that use the concept. They are all very small and similar in size. However, some carry their own cranes, and some do not. Some operate with a pusher-pushed barge combination, and some are singular vessels. The Cityport aims to ensure a modal shift in urban freight transport. For this reason, ships using the Cityport must be adapted to the navigational conditions of the urban area.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

The logistical concept offering a location as a hub to tranship from truck to small barge is the move of a frontrunner. Furthermore, using small barges in inner cities offers key benefits over congesting and polluting road transport. With all the services Cityport offers, they can play an important role in the inner-city logistics of the future. Micro hubs or stadshaltes are used within the concept. Essentially these are all dedicated point to load or off-load cargo from the canal to the shore. Often, pontoons are used because the old quays cannot offer the space and loading capacity (weight limits). These locations can have their own crane on-site or a vessel needs to bring it's own crane (sometimes a combination). One missing link in the a-to-b story is the link between true inland ports and inner cities.

In Utrecht for instance, the largest inner-city port-location is the Liesboschhaven. It facilitates a very large share of the vessels going into the inner city and is significantly larger than a micro-hub or Stadshalte (it can be reached by truck and can handle multiple small vessels or even some larger ones). However, these vessels need to be so small that they cannot operate well on large fairways. In Utrecht this is a problem because the true inland port, called Lage Weide,

Criteria	Evaluation
Logistics/Coordination	**Very Good**
is located out of the inner city and to reach it the Amsterdam-Rhine Canal must be used and crossed. In practice, this link in the chain is not comfortably closed. An in-between-sized vessel is needed to push/pull small craft (perhaps bound together as seen in push barge operations) between inland port and inner city.	

Criteria	Evaluation
Competitive position	**Good**
The Cityport concept benefits from the existing weight-limit on trucks for the inner city in Utrecht. Moreover, there is an ever-growing desire to decrease traffic and its emissions in the inner city. This concept, especially when barges are zero-emission fits well into the view of city, consumers and shippers. However, electrical vans and cargo bikes might be able to partially answer the same demand and are not bound to quayside locations. But even when truck operation is electrified, it leads to congestion and is dependent on the availability of parking spaces, which limits its flexibility as city centre traffic increases. Here, the Cityport can dynamically help to create intermodality, and can also serve as a logistics centre for truck operation. However, the concept still requires extra handling movements compared to truck-only operations.	

Criteria	Evaluation
Business model	**Good**
The hub is white-label and charges for its services. It is operated by a private entity and is able to offer solutions for waste management, transport of goods, transport to and from building hubs with materials and waste and can deliver modular power sources placed on pontoons. The potential for waterborne urban logistics and the wide range of urban logistics services offered contribute to a solid business model.	

3. Conclusion

Valuable logistical lessons have been learned through the substantial number of operational movements to and from the hub. Small pontoons are good solutions to make almost every quayside location in the inner city suited to handle loading and unloading of barges.

The roll-out potential is big. A Cityport equivalent concept could serve any city as long as the cities are connected to the canal network and as long as a location for a hub can be found. The latter might be the biggest problem here since a potential hub location has many similar criteria to attractive residential building areas (relatively close to inner city, reachable by truck/car, enough space). In the Netherlands, potential residential building locations are scarce and are by local policy makers often prioritised over logistic needs and wants. Contributing characteristics are mainly the ability to transport goods into inner cities over water in a time where restrictions on trucking in these locations get more and more stringent.

Citybarge

1. Introduction

The Citybarge idea first started out as a wish to use small canals in Dutch cities to distribute cargo. The benefit of this is a decrease in traffic by heavy trucks in old city centres. However, Citybarge also includes the concept of battery electricity, meaning that tank-to-wake zero emissions are realised which has benefits for health and climate.

The case is that of small push boats (electrically powered) that move small nonpropelled barges around the old canals. Furthermore, the infrastructure market is interested in the product. The first Citybarge One is in operation for 3 years.

Image of the service

The Kotug Citybarge (source: Final Report for the IDB Dutch Subsidy Scheme)

Key Facts			
Name of service	Citybarge	Crew	1-2
Operator	Kotug Citybarge	Automation	Low
Market Segment	Mixed (Inner-City Logistics)	Port equipment	Differs per Case
Region	Rhine (Netherlands)	Return Flows	Waste.
Status	Operational	Last Mile Transport	Differs per case ((electrical) truck, other)
Launch year	2021	Waterway infrastructure (Navigation Conditions)	Very small waterways, infra-dependent: bridges, locks must be in operation
Barge Capacity	Depends on non-propelled barge	Service frequency	Differs per case
Fleet Size	7	Transport volume	40-80 tonnes per trip
Ship Length	5.7m	Societal benefits (e.g. mitigated emission)	Zero TTW emissions
Draught	0.5m	Supportive regulatory framework	Has certification (CvO) and follows ESTRIN
Propulsion	Electric azipods 15 kW *2	Financial support	Not known in all cases. Has had support from

Key Facts			
			schemes (NL govt) and other support by local governments.
Equipment	Handling equipment from the shore needed.		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**
Locations are needed where the barge can dock during loading and unloading. These can best be facilitated by pontoons or at specific quay walls, not all quay walls are low enough for docking. Here, the concept benefits from the fact that it has very little infrastructural needs. Fees are usually not paid; stakeholders are kept in the loop and incidentally governments pay some support to quay owners. Regulations focussing on residential buildings make it harder to reserve areas for transshipment.	

Criteria	Evaluation
Cargo/passenger flows	**Good**
Inner cities need many goods to be transported in. This applies to various market segments: supply of construction sites with building material (large building projects going on in the Netherlands), delivery of shops (big inflow volume of goods needed), waste disposal (cities produce an increasing volume of waste). These mixed commodities can all be moved by Citybarge as it is already done in some Dutch cities. There is a high cargo volume in urban logistics which means a substantial potential for the extension of the Citybarge concept. Regarding an increasing demand in future, the transport volume of the service can be easily scaled up, since more push barges of this concept can be quickly realised.	

Criteria	Evaluation
Infrastructure	**Good**
The small size of the vessel and the barges allows for operation on small waterways and has little requirements for infrastructure. The vessel can be loaded and unloaded at small pontoons or quayside locations that do not take a lot of space and provide little disturbance to people working, living or recreating in the direct environment. There remains a need for cargo transshipment, but the equipment used is also relatively (very) small. Similarly, the vessel can move through small locks and under small bridges that do not need to be adapted for this. Transshipment is often done by using containers for building debris or similar containers that can be on-and offloaded on and by a truck. No fixed facilities are needed like cranes at the moment. This not only enables a flexible logistics concept, but also reduces the environmental impact of infrastructural adaptions, which must be done. Similarly, the vessel can move through small locks and under small bridges that do not need to be adapted for this.	

Criteria	Evaluation
Vessel	**Very Good**
The combination of a small electrical pusher and small barges enable the operation in small inner cities. This is also a scalable concept because bigger pushers are already being developed. Loading, unloading, and sailing still require trained staff and might benefit from automation, however the small size of the vessel make it easier to operate than larger vessels. The fact that the vessel operates zero-emission on a tank-to-wake level due to its electrical power supply is a large contributor to the attractiveness of the concept over road transport. Electric propulsion also provides the advantage of further reducing noise annoyance for local residents. On the smallest versions, no accommodation is available, but that allows the vessels to move under bridges and the crew does not stay overnight.	

Criteria	Evaluation
Logistics/Coordination	**Good**
The logistical concept builds on the use of small barges in inner cities and offers key benefits over congesting and polluting road transport - especially a zero TTW emission barge. However, in many cases, handling and last mile transport is still needed. Depending on the type of cargo this needs to be done by a truck (bulk) that might be electric or by small electric vehicles or cargo bikes (consumer goods). The possibility to combine flows in and out of the city is a clear advantage. Furthermore, almost all goods that need to be moved in or out of city centres might be applicable. However, potential users need to significantly adapt their supply chain operations to be able to make use of the concept.	

Criteria	Evaluation
Competitive position	**Good**
There is a competitive advantage for small scale IWT in inner cities, because of the further uptake of environmental zones, closing city centres for heavy road traffic, electric-only small road transport for inner cities, focus on zero-emission, decreasing road traffic and health benefits in inner cities. Due to a lack of space on land, it becomes more attractive to make use of the space that canals still can offer for the transport of goods. However, canals in cities are also used to recreate and many transport movements and loading and unloading locations might bring the concept into conflict with current users. With regard to the competitive situation in terms of costs the use of small scale IWT services is significantly more expensive than truck operation only. However, truck operation is limited (and will be more limited) in inner cities and sometimes governments even pay the price difference. The concept has one significant plus: the non-propelled barges can be left on the quay for hours or days to be used as storage. A truck visiting a site in the inner city has to move on within a very strict timeframe. This causes strain on the process of the building site. This is a competitive advantage that makes good a part of the higher costs.	

Criteria	Evaluation
Business model	**Good**
The company is operated by a private entity but has relied on subsidies at least in the past. Currently, it is not clear if financial support is still received, but governments do support the company in achieving its goals. The business model works well because it offers a unique opportunity to switch away from roads in inner cities - something that is likely to become more attractive in the future.	

3. Conclusion

The concept has proven itself to be scalable: starting out with small electrical push-barges, Kotug is now working on launching bigger versions of electrical push-barges. In inner-city transport, the concept is one of the first movers regarding zero-emission barge transport. Logistically, the push-barge concept allows for flexible operations where the pusher can push one barge in and another out of the city. The combination of logistical streams in and out of the inner city is thus captured really well. Additionally, barges can serve as floating storage within the city where trucks can't offer this service, giving IWT operation a competitive advantage.

Electrical pushers certainly have roll-out potential because of their versatility. The logistical inner-city concept offers shippers in inner cities ways to avoid the ever-congested road network and limitations on truck usage. Left behind non-propelled barges offer time-restraint free space to store cargo and/or debris on canals near building sites.

Green Wave Ghent

1. Introduction

Urban Waterway Logistics develops various vessels that are specialised for an urban environment with various limitations such as low bridges. In Ghent, Urban Waterway Logistics offers the Green Wave Vessel for the transport of building materials and waste, thus helping to replace truck traffic in urban transport. Urban Waterway Logistics is also involved in the test delivery of parcels on Hamburg's canal system as part of the Decarbomile project and is involved in the development of autonomous vessels within the frame of the AVATAR project together with other stakeholders as Seafar and more. Four more ships are to be developed in the future. Various developments have been initiated in Ghent to favour waterborne transport. For example, Urban Waterway Logistics has developed loading points within Ghent that enable loading and unloading with micro-hubs. A multipurpose city logistics hub is also to be developed in the future. With these developments, Urban Waterway Logistics can help to support the city's vision to promote sustainable mobility along the waterway.

Key Facts			
Name of service	Green Wave Avatar	Crew	1
Operator (Research and Development Consortium)	Urban Waterway Logistics	Automation	In the future remote control
Market Segment	Mixed	Port equipment	Portable crane for inner city handling
Region	Rhine	Last Mile Transport	Using trucks, a truck with a crane and cargo bikes
Status	Operational	Return Flows	Waste
Launch year	2023	Waterway infrastructure (Navigation Conditions)	In Ghent navigation limited due to low bridges and low draught
Barge Capacity	25 tons	Service frequency	Several times per week
Fleet Size	1 in Ghent, 1 in Hamburg (4 more will follow in different projects)	Transport volume	No figures yet
Ship Length	15 meters width 4 meters	Societal benefits (e.g. mitigated emission)	Mitigation of truck traffic and avoidance of Co2 emissions as well as traffic noise
Draught	In Ghent draught limited to 40 cm	Supportive regulatory framework	Limitations for truck operation and the development of sustainable visions by city authorities
Propulsion	Electric	Financial support	For operation there were subsidies in the start-up phase

Key Facts			
Equipment	Ballast tanks are important		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**

The new type of ship, which was developed, did not require a complicated authorisation procedure for the navigation on the waterway. Normal licences could be obtained for the transport of building materials and waste. This means that there are no regulatory obstacles for the existing service in Ghent. Administrative conditions in Flanders are particularly favourable for research into autonomous shipping, as the Flemish waterway authorities have designated the entire area as a test region.

Criteria	Evaluation
Cargo/passenger flows	**Average**

Five companies and 900 construction companies can be provided with transport solutions. Although the loading capacity of the Green Wave vessel is limited to 25 tonnes, which corresponds with an average truck. The transport volume is adaptable to an increasing demand by increasing the frequency, while transport volumes on the road are limited by an increase in congestion and legal truck operation limitations. Furthermore, an estimate of the transport volume is not yet available. Due to a lack of estimates on transport volumes and their potential, it is difficult to make an assessment.

Criteria	Evaluation
Infrastructure	**Good**

Ghent is a city that has historically grown with the trade on the waterway. Accordingly, the waterways are closely linked to the city, which gives urban logistics on the waterway greater flexibility than in other cities. At the same time, the historic city centre also presents challenges. For example, there are various bottlenecks for navigation on the waterways. One problem are low bridges, with the lowest bridge height of 1.10 metres, which restrict the loading height of ships and the height of loadable palettes. The draught in Ghent is also limited to 40 cm. The varying height of quay walls also poses a challenge for the transshipment. This is why Urban Waterway Logistics, with the support of the city of Ghent, has developed its own areas for unloading, with micro hubs serving as consolidation points for last mile operations. There are also plans to develop a multipurpose city hub with a bimodal connection to the waterways and motorways. This hub will be also linked to the city logistic with connections to important roads, which leads into the inner-city. The service has to adapt to difficult conditions. At the same time, Urban Waterway Logistics is developing micro and city hubs.

Criteria	Evaluation
Vessel	**Very Good**

During the development of the Green Wave Avatar ship, particular attention was paid to adapting it to the navigation conditions in Ghent with its low bridges. With a flat superstructure, the ship can pass any bridge depending on the height of the pallets. The Green Wave Vessel is also adapted to the situation with a maximum draught of 40 cm. Besides that, the Green Wave vessel uses electric propulsion for sustainable and green operation that avoids CO2 emissions. Development for semi-autonomous transport with remote control is planned. This would also improve the cost-effectiveness of transport by reducing the number of personnel required from one captain per vessel to one captain for three vessels. Urban Waterway Logistics is also cooperating with other stakeholders to research autonomous transport as part of the Avatar research project and also provides ships for Seafar, universities and other organisations such as the DLR for testing sensors, 5G and other devices or equipment needed for autonomous shipping. The specific adaptation to the challenging infrastructural environment, the electric and clean propulsion and the exploration of the operation in remote control open up potential for the IWT service.

Criteria	Evaluation
Logistics/Coordination	**Good**

Efficient logistics can promote the competitiveness of the service. Aspects here include loading and last mile operations. Loading is difficult in places due to differing quay heights. In the initial phase, a mobile crane was able to help unloading the transported goods. However, a mobile crane, i.e. a truck with an on-board crane, is also affected by the time restrictions of truck traffic, which limits the time flexibility of waterborne transport. Competitive advantages would be lost as a result. For this reason, loading ramps were installed on the ship, which enable unloading with rollers at a suitable quay height. In addition, construction cranes could also be used for unloading when delivering to specific construction sites. Transshipment points, provided by the city of Ghent, also favoured the logistics. These areas are complemented by micro hubs, which favour the consolidation of the last mile operation. Various means of transport are used in the last mile operation, ranging from trucks to electric vehicles and cargo bikes.

One logistical advantage is that waste is taken along on the return journey of the ships, which increases the efficiency of the logistics concept. Special containers are being developed for this purpose, which can be loaded onto the ship, thus separating types of waste from each other and favouring the process. The logistics here lead to the usual problems with loading and last mile operations. At the same time, solutions have been developed that preserve the time flexibility of ship transport.

Criteria	Evaluation
Competitive position	**Good**
The Green Wave vessel was developed with the aim of establishing modal shift from road transport to waterway transport in urban environments. Waterborne transport with electric ships has many advantages, such as the avoidance of noise, Co2 and traffic jams. There is potential for a balanced competitive position, as regulatory restrictions for truck transport promote the advantages of sustainable transport more strongly. In Ghent, for example, an emissions zone has been established that only allows truck traffic between 7am and 11am. This allows barges to offer more flexible transport times. Although the ship is limited to a loading capacity of 25 tonnes, it can make more efficient use of this limited loading capacity than the truck thanks to its greater time flexibility. The costs of operating inland waterway transport are higher than the costs of operating transport by trucks. This applies to most cases and is not the only criterion for the assessment, as social advantages must also be included in the consideration. The social benefits within this service are there, leading to public acceptance. Public acceptance is important to also gain public support, as demonstrated in the development of loading points here.	

Criteria	Evaluation
Business model	**Good**
The transport of building materials and waste in Ghent is organised and operated by Urban Waterway Logistics itself. There are five construction companies that are clients for the service in Ghent, where 900 construction companies can use the service of construction material delivery. Urban Waterway Logistics also develops the necessary infrastructure itself, with the help of the city of Ghent. At the beginning of the start-up phase, the city of Ghent subsidised the service for transporting building materials and waste. These subsidies have expired, but the company continues to operate and demonstrates a sustainable business concept.	

3. Conclusion

There is potential to expand services comparable to those in Ghent, as the infrastructural conditions in Ghent are not unique. Many cities are interested in similar services. In addition to the service in Ghent, Urban Waterway Logistics is also involved in the development of a service in Hamburg as part of the Decarbomile project for parcel deliveries by waterway. This shows the potential for comparable services also for other market segments and regions. There are various challenges that need to be considered during implementation. The challenges here are low bridges, a shallow draught, and various bottlenecks. This results in a trade-off, as the disadvantage of the structural limitations leads to a lower loading capacity, but at the same time allows greater flexibility and access to more clients. Here the Green Wave vessel provides a well-adapted ship concept, which operates on difficult navigation conditions but can provide logistic solutions.

The increase in efficiency and the regulatory limitation for truck transport operation to increase the sustainability can compensate for these disadvantages in the future. This also applies to the introduction of autonomous ship management such as remote control, which reduces transport costs. Urban Waterway Logistics is in the right position to explore this strategy, which leads to a promising case. In addition to bottlenecks, the development of inner-city loading points and micro hubs is necessary. Even if these only take up a limited amount of space, space reserves are limited in every city. This is why public acceptance, and the support and assistance of public authorities are important.

Services of this kind can promote public acceptance with the social benefits they bring. Promoting this should be in the interest of public authorities.

Kotug E-push convoy (Cargill Zaandam cocoa supply)

1. Introduction

The E-Pusher (type M for medium) and four E-Barges became operational in June 2023 for the zero-emission short-range transportation of cocoa beans between the Port of Amsterdam and the production facility of Cargill in Zaandam. It concerns a push convoy which covers one pusher tug and four self-propelled electric barges each capable of transporting over 1,000 tons of cargo each. The pusher tug is equipped with a 2mWh swappable battery container (supplied by EST Floattech). The CO2 reduction is estimated to be 190 tons per year, avoiding 15,000 truck movements per year. The barges are equipped with a fixed installation of 281kWh each or a total of 1,124kWh. Charging is done at the production facility with green electricity from wind. The battery is charged by “standard” AC shore power connection, by DC high power charging (up to 1mW per hour) or to be changed with a different energy container within a few minutes. Cargill is the first company with this fully electrified industrial setup for inland shipping using a push convoy approach.

Images of the service

Source: KOTUG[13]

Key Facts			
Name of service	Kotug E-push convoy (Cargill Zaandam cocoa supply)	Crew	2
Operator	KOTUG International	Automation	Medium
Market Segment	Other (Short-range)	Port equipment	No special port equipment needed
Region	Netherlands (Rhine corridor)	Last Mile Transport	Suitable
Status	Operational	Return Flows	No
Launch year	2023 (June)	Last Mile Transport	Not applicable
Barge Capacity	Depends on non-propelled barge, up to 5,500 tons	Waterway infrastructure (Navigation Conditions)	Canal system
Fleet Size	1	Service frequency	Daily

[13] https://binnenvaartkrant.nl/cargill-zet-e-pusher-van-kotug-in-voor-vervoer-cacaobonen

Key Facts			
Ship Length[14]	16m (width: 7.4m)	Transport volume	1,000 tons per trip
Draught	1.35m (min air draft 4.3m)	Societal benefits (e.g. mitigated emission)	Reduction 1500 Truck km and 190 t Co2 p.y.
Propulsion	2 electric azipods upto 300 kW	Supportive regulatory framework	Has certification (CvO) and follows ESTRIN
Equipment	Modular build electric propelled push tug using 2MWh battery container	Financial support	Not known in all cases. Has had support from schemes (NL govt) and other support by local governments.

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**
The vessel concept is approved within legislation. Locations are needed where the barge can be recharged from shore (cold ironing) or swap the energy container. The latter may require administrative requirements.	

Criteria	Evaluation
Cargo/passenger flows	**Very Good**
For Cargill, a cocoa supply equivalent to 15,000 truck transports has been moved to IWT by using an electric convoy. This concept can be used for any commodity which can be transported in a barge. It is flexible as it concerns the E-pusher, so it is decoupled from the cargo carrier and the type of commodity. KOTUG indicates that it is a cost-efficient concept and the first zero emission IWT solution based on a commercial competitive business case without the need for a subsidy contribution. Hereby it can compete with road cargo and is supporting the modal shift towards IWT services.	

Criteria	Evaluation
Infrastructure	**Good**
The overall vessel concept is flexible regarding the available infrastructure waterway dimensions as it can select barges to push which fit to the available dimensions (e.g. locks which need to be passed). The main concern with respect to the infrastructure is the availability of locations where electric containers can be swapped or recharged. However, due to its “smart” switchboard it is able to charge both AC and DC and in case there is no infrastructure, a fall-	

[14] See also https://www.kotug.com/towage/inland-towage/vessel-specifications-e-pusher-m/ for more details and drawings of the E-pusher type M

Criteria	Evaluation
Infrastructure	**Good**
back option is to use other energy solutions, like using biofuels and combustion engines which can generate the required electricity power to feed the outboard thrusters.	

Criteria	Evaluation
Vessel	**Very Good**
The E-Pusher concept benefits from its modular and scalable design. The electric pusher tug is powered by swappable energy containers. The hull is made from light weight material (high density polyethene (HDPE)) which reduces the draft and minimizes fuel usage of the vessel while being designed at a maximum draft of 1.35 meters considering shallow water conditions. The combination of the multi-purpose electrical pusher and barges enable the operation in a wide area. By using barges, the E-Pusher concept contributes to a more efficient operation compared to traditional vessels increasing cargo capacity and improving crew efficiency. The convoy allows flexibility by adapting the convoy to waterway dimensions and logistic needs. The fact that the vessel operates zero-emission on a tank-to-wake level due to its electrical power supply is a large contributor to the attractiveness of the concept over road transport. Besides the power system, several other innovations are implemented as well, such as the use of lightweight materials and modular design and construction, the use of standardised containers as living environment for the crew.	

Criteria	Evaluation
Logistics/Coordination	**Very Good**
The concept seems very well suited to be deployed on other routes as well, replacing conventional pushers but also replacing conventional motor vessels. It may therefore fit in various logistic chains considering the flexibility of convoy composition with respect to logistic needs. However, to perform TTW zero-emission, there needs to be availability to recharge battery during idle time or swapping of battery containers. The latter lack of availability of these facilities now, may limit the roll-out. Together with Shell they will nevertheless implement a 1mWh high-capacity charging station in the port of Amsterdam to enable fast charging options and on the other hand, the pusher may use other energy solutions, such as combustion engine gen-sets using biofuels which provide more mWh of energy at the same container dimensions which makes it less depending on available facilities.	

Criteria	Evaluation
Competitive position	**Very Good**
For clients and companies willing to invest in zero-emission performance transport, this turns out to be a competitive concept - including over short distances - even without subsidies being granted. The flexible concept of using barges and a pusher enables costs reductions on crew and machinery. Compared to using several motor vessels or to one pusher with a set of barges, the electric pusher performs better regarding the reduction of operation costs. This also enhances the competitive position to truck operation, which cannot offer a sustainable clean transport service here.	

Criteria	Evaluation
Business model	**Very Good**
The electric convoy with the E-pusher M provides a solid base for feasible business models developing (short-range) IWT and stimulating modal shift from road to waterway. The concept offers a flexible opportunity to design a waterborne transport system optimised for a route and logistic flow. Moreover, it benefits from the zero-emission technology.	

3. Conclusion

The concept has proven itself to be scalable: starting out with small electrical push-barges, KOTUG deployed the bigger (“M” sized) version of electrical push-barges in this project. The E-Pusher M and L have been designed for the usage of standard 20ft (high cube) energy containers for energy production and/or storage. The vessel is equipped with a “smart” switchboard able to absorb both AC or DC energy to accommodate different types of energy sources ranging from more traditional stage V diesel, LNG, hydrogen and batteries.

Logistically, the push-barge concept allows for flexible operations where the pusher can push different types of commodities and different sizes of barges. It may also choose to select another type of energy carrier and convertor (e.g. combustion engine gen-sets, H2FC) based on the availability and preferences of the client or operators. It therefore can anticipate to new developments in the field of energy technology and also energy prices. Furthermore, the design of the vessel allows more quick production in The Netherlands having a lower CAPEX over conventional vessel designs.

3.3.6 Good Practice Case for urban and short-Range IWT Services for Container

Alphenaar Heineken Boat

1. Introduction

The Alphenaar is the first Dutch barge to use interchangeable energy containers for propulsion. The Alphenaar sails between Alphen aan den Rijn and Moerdijk for beer brewer Heineken, Zero Emission Services' (ZES) first end customer. The barge operates a short-range container service connecting the Heineken brewery with the port of Moerdijk substituting last-mile truck operation. The Alphenaar is a green ship that can sail emission-free for five hours with a 2.4-megawatt battery pack.

Images of the service

'Alphenaar' Foto, Ries van Wendel de Joode.

Key Facts			
Name of service	Zero Emission Services (ZES)	Crew	2 to 3
Operator	Combined Cargo (CCT) Terminals in Moerdijk	Automation	No
Market Segment	Container (Short-range)	Port equipment	Charger, crane
Region	Rhine (South Holland)	Last Mile Transport	Road
Status	Operational	Return Flows	Empties
Launch year	2021	Waterway infrastructure (Navigation Conditions)	Canal
Barge Capacity	104 TEU	Service frequency	Daily
Fleet Size	1	Transport volume	Per trip, 52 containers of beer (2.5 million bottles). From Moerdijk, the beer goes to Rotterdam and Antwerp for export.
Ship Length	90 m	Societal benefits (e.g. mitigated emission)	Reduction of 1000 t of Co2 and 7 t of NOx p.a. per vessel[1]
Draught	2 m	Supportive regulatory framework	Dutch green deal
Propulsion	Battery electric	Financial support	Yes, from growth fund

Equipment	Oswald Electromotor 2 x 544 pk		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**
Due to the IO/lithium batteries in the Alphenaar, ADR-regulations (Dutch regulations for waterborne transport of dangerous goods) apply to the ship. However, in an interview CCT shared that no issues were encountered with this whatsoever, including in the harbours that the ship moors/arrives at. The ship is ADM/ADR certified and so is the personnel. The Alphenaar also has a diesel-electric capability. The aggregate (diesel) is a back-up for the electric battery, because of the still somewhat limited range of batteries. However, a contact person from CCT estimates that the ship as of now operates electric most of the time (at least 90%).[15]	

Criteria	Evaluation
Cargo/passenger flows	**Good**
With Heineken (beer) as a launching customer, there is a sufficient base in terms of cargo supply. The beer is loaded in the Alphenaar straight form the Heineken factory, and it is delivered directly to CCT's terminal in Moerdijk (or to Rotterdam, Antwerp). From there it can be distributed (deepsea). Although the Alphenaar's service is a first of its kind, and charging infrastructure is still scarce, ZES is currently building a network of charging stations. CCT faces the challenge that the alternative fuels market in Europe, but even more so in the Netherlands, is still in an early phase; the Alphenaar, as an electric container ship, is a 'new product'. Therefore, this electrified short-range container transport service over water included a lot of experimenting and encountering small practical hurdles (learning by doing). For example, the 'switching' time between battery and diesel operation had to be shortened by request of the shipmasters (this cannot take 10 seconds, as then the boat is un-propelled during that time). And another example is the automated process of mooring and docking to a charging point (more room for error due to lack of human interference).	

Criteria	Evaluation
Infrastructure	**Very Good**
The inland waterway transport service offers the opportunity here, to utilise existing infrastructure such as terminals and cranes for loading and unloading containers. This existing infrastructure enables the service to operate efficiently without incurring additional costs for the construction of new facilities. One challenge is the requirement of charging stations to power	

[15] https://www.electrive.com/2021/09/08/first-inland-vessel-fitted-with-zes-battery-containers-hits-the-water/, last access 8th of April 2024

Criteria	Evaluation
Infrastructure	**Very Good**

the ships. To this end, ZES, in collaboration with stakeholders such as BCTN, is currently building new ships and a network of charging stations in Alblasserdam, Rotterdam, Den Bosch and Antwerpen, to extend the range of the service and further improve flexibility. By using interchangeable energy containers, the service can also be easily extended to other waterway routes without the need for major infrastructural adjustments. This enables a scalable and adaptable infrastructure that meets the needs of the growing zero-emission waterway transport sector.

Criteria	Evaluation
Vessel	**Very Good**

The “Alphenaar” ship plays a key role in the green transformation of transport services. By using interchangeable battery containers, known as ZES packs, the ship enables zero emission operation. This approach supports the logistics concept for (short-range) inland waterway transport by offering a sustainable alternative to conventional shipping and significantly reducing CO2 emissions. The concept of the vessel is based on specialised research and development in the field of zero-emission shipping, with companies such as Wärtsilä and Engie playing a key role in the development of the ZES packs and charging infrastructure. The ship’s innovative design, which enables the use of battery containers, demonstrates a forward-looking approach to shipping and lays the foundation for an environmentally friendly transformation of inland waterway transport.

One obstacle here is the still inadequate capacity of the battery containers, which is not yet sufficient to operate a complete route. Future technological developments can boost the potential here. Through the vessel’s adaptability to different types of energy containers, including potential future technologies such as hydrogen or ammonia, it also demonstrates a willingness to adapt to evolving trends and technologies to promote a sustainable future. There have been issues recently with the batteries, which caused the Alphenaar to temporarily rely solely on diesel propulsion for its service. However, according to CCT this is all solved now, the new batteries are improved, and the vessel has been operating almost fully electric again with no notable issues.

Criteria	Evaluation
Logistics/Coordination	**Good**

The logistics concept has a clear focus providing efficient short-range container transport in the hinterland of seaport. ZES has signed a long-term contract with Heineken to transport beer from the brewery in Zoeterwoude via the CCT terminal in Alphen to the port of Moerdijk. From Moerdijk, the beer goes to Rotterdam and Antwerp for transport which enables worldwide distribution. A last-mile transport concept is not required, as the Alphenaar travels directly from the Heineken brewing factory to the CCT container terminal, and vice versa.

For the zero emission transport the provision of infrastructure is required for the operation of battery-powered inland vessels. Smooth, environmentally friendly transport is ensured by the introduction of charging stations along the route, where the battery containers can be

Criteria	Evaluation
Logistics/Coordination	**Good**

exchanged and recharged. This enables a continuous energy supply for the ships and minimises downtime.

ZES ships are primarily used for long-distance transport on inland waterways. The electrical infrastructure must be sufficiently dimensioned to ensure smooth operations and avoid bottlenecks. In addition, staff training may need to be provided to ensure that the battery container exchange is carried out safely and efficiently. Overall, the ZES logistics concept demonstrates an innovative approach to the integration of zero-emission inland waterway transport and could make an important contribution to reducing the environmental impact of freight transport.

Criteria	Evaluation
Competitive position	**Good**

This example shows that short-range container IWT can be competitive considering road congestion. This service benefits from the long-term agreement with Heineken and the high utilisation with the export containers of the Heineken brewery. Moreover, it has to be considered that an electric drive as used in this service is still more expensive than a conventional drive. However, this allows for zero emission and creates social benefits.

The higher cost for electric propulsion of ships is mainly related to the acquisition cost of the battery containers. Furthermore, the range is smaller than in conventional diesel propulsion. The deployment area is mainly on canals (low flow) and shorter distances with scheduled services. At this early stage, electric IWT services cannot compete without a party willing to contribute to this. This could be a large shipper motivated by the idea of sustainability. Also, governmental subsidies and support could help to increase the competitive position. For example, one-third of the grant money from the National Growth Fund has been labelled for ship owners and shipping companies to make modifications to inland vessels to operate on ZES battery containers.

Criteria	Evaluation
Business model	**Good**

The business model behind the use of ZES for the transport of goods on inland waterway vessels involves close cooperation between various parties. The operators of the system are closely linked to Heineken, a major end customer for the transport of export beer, ZES, a consortium of companies including ENGIE, ING, Wärtsilä and the Port of Rotterdam Authority, was established to provide zero-emission solutions for inland shipping. The Dutch government contributes through subsidies for more sustainable transport. Heineken supports ZES with signing the long-term transport agreement and an initial contribution to the development costs of the first ZES powered ship of its carrier CCT. CCT will not charge handling fees for loading and unloading the first ZES powered ship.

Criteria	Evaluation
Business model	**Good**
Heineken is the main client for the transport of its export beer from the brewery in Zoeterwoude to the destination ports. Heineken has contributed significantly to the success of the project through long-term transport contracts and financial support. The long-term cooperation between Heineken and the logistics company CCT demonstrates the trust and commitment of both parties to promote sustainable transport solutions. The business model does not rely exclusively on public funding, although ZES has received support from the Dutch Ministry of Infrastructure and Water Management. Funding also comes from private investment, including contributions from Heineken and other companies in the consortium. In addition, ZES has received access to funding from the National Growth Fund to commercialise the project and further develop the system. Overall, the ZES business model for the transport of goods on inland waterway vessels demonstrates a successful partnership between private companies, end customers and public authorities. The involvement of various stakeholders drives the development and implementation of sustainable transport solutions and strengthens the business model.	

3. Conclusion

Since September 2021, the barge 'Alphenaar' has been shuttling 62 kilometres between Moerdijk and Alphen aan de Rijn with cargo from Heineken on Zero Emission Services' battery containers. This service is a successful example for short-range waterborne container operation in the hinterland of seaports. ZES is a provider of products and services for zero-emission shipping, such as battery containers used in barges. The aim is to eventually create a network of charging stations where skippers can exchange their empty container battery for a full one. Among other things, ZES received 50 million from the National Growth Fund to market the system. The 'Alphenaar' is the first vessel to sail with the batteries. This means that all that has been done so far, was very new. For example, CCT mentioned in an interview that the idea was to make a universal product, so that all types of plugs can be connected for charging. However, during operation, they noticed that the plug is not positioned ideally. These kinds of things can be taken into consideration in a later stage.

New versions of both the batteries and the charging station are coming. The new charging station is duplicated and can charge two containers simultaneously in up to three hours. The grid connection is 2 MVA. The new containers also have more capacity of 2.9 MWh. The logistics system and safety have also come under scrutiny in the two years the 'Alphenaar' has been sailing. The first pack of batteries had to be removed temporarily because of damage and other problems. The new batteries have a fire extinguishing system and can be monitored remotely. Skippers wanting to change a battery container will soon be able to log on to a platform linked to the terminals, so they will not have to wait for a full one. Further, the ‘switching’ time between battery and diesel operation had to be shortened by request of the shipmasters (as then the boat cannot be un-propelled for 10 seconds). And another example is the automated process of mooring and docking to a charging point (more room for error due to lack of human interference).

According to the targets that the National Growth Fund linked to the ZES grant, 14 charging stations and 75 battery containers should be in operation by 2026. Ebusco announced in late August that it would make the new charging station and docking stations for ZES, after going through a tender process. The developer of electric buses, battery storage and charging systems will supply 10 'docking solutions' for now, with an option for an additional five. Besides a charging solution, ZES has also been looking for a way to provide ships with shore power during loading and unloading, from 2030 an obligation for terminals. For this, the Ebusco Discharge Station is

used in combination with a charging station. The shore power facility also operates on a ZES pack, a 20-foot container containing electrical equipment, which can be used to supply ships with power during loading and unloading.

3.3.7 Good Practice Cases for passenger urban IWT Services

Flying Boat/Commuter Ferries in Stockholm

1. Introduction

In Stockholm, the management of public transportation falls under the jurisdiction of the Stockholm Region, overseeing various aspects of regional governance, including healthcare and transportation. Under its umbrella, several brands are associated with various modes of public transportation ensuring seamless operation of a comprehensive transit network in the Stockholm region. SL operates key urban waterborne transit lines such as 80, 82, and 89, and plans the development of additional routes in the future. These services are essential for connecting the diverse urban regions within the Stockholm area, including the islands of Lidingö, Djurgården, and Tappström. Notably, Line 80 was integrated into SL's transport service in 2010 after being taken over from Waxholmsbolaget, marking a significant milestone in the coordination of urban water transportation within Stockholm.

Meanwhile, the test pilot of integrating the Candela P12, an innovative hydrofoil-based passenger ship, into Stockholm's existing boat lines represents a significant advancement in urban water transportation. With its ability to minimize energy consumption, reduce operational costs, and offer higher speeds, the Candela P12 addresses key challenges faced by traditional passenger ships. This integration reflects Stockholm's commitment to embracing innovative solutions to enhance urban mobility and meet the evolving demands of its residents and visitors.

Image of the service

A passenger service vessel landing at Slussen in Stockholm (Source: SL)

Key Facts			
Name of service	Stockholm Passenger Transport	Crew	SL: 2, Candela P12: 1
Operator	Rederi AB Ballerina, Djurgårdens Färjetrafik AB, Blidösundsbolaget	Automation	No Automation

Key Facts			
	AB on behalf of Storstockholms Lokaltrafik (SL)		
Market Segment	Passenger Transport	Port equipment	Differs per station (jetties, quay walls or pontoons)
Region	Remote Waterways (Stockholm)	Last Mile Transport	Integration into the public transport routes of SL
Status	Operational	Return Flows	Not relevant
Launch year	SL: 2010, Candela 2014	Waterway infrastructure (Navigation Conditions)	25 piers, 2 terminals, waterways can be iced in Winter
Ferry Capacity	SL: most vessels 340 passengers but up to 500, Candela P12: 30	Service frequency	3 Lines (2 more planned)
Fleet Size	20 vessels on SL-lines (4 owned by Waxholmsbolaget)	Transport volume	5 Mio Passengers per year for SL boat lines
Ship Length	SL: up to 40 m, Candela P12: 12 m	Societal benefits (e.g. mitigated emission)	Offering alternative and more sustainable public transport, Candela can offer fast and clean transport.
Draught	Shallow draught on some lines	Supportive regulatory framework	Temporary Speed Limit Exceptions for Candela P 12
Propulsion	Mixed (mostly Diesel or HVO), one electric, Candela P12 is electric	Financial support	Funding by regional administration of Stockholm (public service obligation)
Equipment	wheelchair spaces and bicycle parking on board		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Good**
As Passenger Transport Administrator, SL operates bus, tram, metro, rail and boat transport in the Stockholm Region. The responsible bodies are the Traffic Committee and the Special Transport Service Committee. Guidelines for public transport can also be found in the Regional Development Plan for the Stockholm Region (RUFS2050). The ship plays a particularly important role in supplying the islands in the Stockholm archipelago fulfilling public service obligations. Urban transport with SL's ferry lines also plays an important role in making the city attractive and connecting commuters. One administrative restriction is the speed limit. Many passenger ships cause strong wakes.	

Criteria	Evaluation
Administrative Requirements	**Good**

To ensure the safety of others and to minimize erosion with some shoreline areas, there is a speed limit, e.g. 12 knots or less for ferries. This puts ships at a competitive disadvantage, causing them to lose valuable minutes for transportation. The Candela P12 makes it possible to avoid this problem. Thanks to hydrofoil technology, Candela ships cause little or no wakes. For a pilot phase on route 89, where the Candela P12 is to be tested in parallel ferry traffic from 2024, a temporal exemption was obtained to increase the speed to 18 knots in a restricted area, while a major part of the route is unrestricted. An attempt is being made to increase the exception, to 25 knots which is the most efficient speed of the Candela P12.The Candela P12 was initially designed for 18 knots but it was able to obtain even faster speed. Even though the speed limits pose a challenge, SL is responding to this and is trialling a technological solution together with Candela. Operation at 25 knots is possible on a large part of the route. The Candela P12 was designed to accommodate a maximum of 30 passengers. This also applies to safety regulation allowing one-man-operation for the Candela P12.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

Waxholmsbolaget's ferry routes are indispensable for connecting the islands in the Stockholm archipelago. But the SL ferry routes in the immediate urban surroundings of Stockholm also play an important role in public transport and help to fulfil the service mission, e.g. to connect the north-east or a lake in the west of the city. Overall, SL transports 800,000 passengers every day with its underground trains, commuter trains, trams, buses and ferries. The existing urban waterborne services operated by passenger ships cover lines 80, 82 and 89, which are used by around 5 million passengers per year. This represents a modal share of less than one percent. In 2023, 2.3 million passengers used line 80.

Another 2.3 million passengers used line 82, which mainly commutes between the inner-city and touristic sites in Djurgården and thus transports many tourists and leisure passengers. 150,000 passengers are transported on Line 89 per year, which travels further inland and also has many leisure passengers on board. The capacity utilisation of the ships varies greatly in winter and summer. The ferry service plays an important and traditional role in Stockholm, providing important complementary public transport services. New routes are therefore being planned. Test route 83 between Stockholm and the island of Rindö was trialled in 2023 and transported 360,000 passengers. Another planned route is Line 84 between Stockholm and Ålstäket.

Capacity utilisation varies greatly on Line 89, where more than 30,000 passengers sometimes use the ferry in summer months and fewer than 10,000 passengers use the ferry service in winter months. This poses challenges for the service due to temporal overcapacities.

From 2024, a test phase of the Candela P12 in parallel service on route 89 will examine the possibilities offered by hydrofoil technology. The Candela P12 offers space for 30 passengers. The relatively small size of the vessel was chosen in order to optimise passenger capacity utilizations. A fleet of 3 Candela P12 vessels could be put into traffic and replace one 200 pax

Criteria	Evaluation
Cargo/passenger flows	Very Good

vessel. This has the potential to offer a service on the waterway that can adapt more flexible to transport needs, allowing for more frequent departures and capacities adapted to demand, while also serving demand peaks.

The SL ferry service is well established and used by many passengers. Challenges exist in adapting the service to the fluctuating passenger traffic between winter and summer, but SL is involved in a pilot project together with Candela to test innovative technology to trial smaller passenger vessels.

Criteria	Evaluation
Infrastructure	Good

The operation of ferry lines requires transfer points where passengers can board and disembark the ferries. The SL lines use 25 piers and 2 terminals, of which 17 piers can be found on line 80. Line 80 has the Lidingö Bridge (12.5 metres high), which limits the height of some ships. Line 82 uses the Djurgården ferries of Waxholmsbolaget, which require special terminals for transfers. Piers, terminals or quay walls do not belong to the Public Transport Administration but to various parties, such as the Port of Stockholm. The use of such infrastructure is utilised in an agreement. Transfer stations must also fulfil various conditions, which are regulated in the tendering procedure. These include accessibility for passengers on foot, by bike or in a wheelchair, as well as connections to car parks or cycle paths. A particular challenge in the area of the northern Baltic Sea is the freezing of the waterways in winter. This requires icebreaker ships with heavier hulls and higher operation costs.

The Candela P12 is equipped with an automatic hydraulic gangway that can be orientated at different angles and can therefore flexibly access piers, jetties, quay walls or pontoons. Overall compared to smaller waterways, there are fewer bottlenecks that could restrict traffic. At the same time, vessels are adapted to the infrastructural demands and the navigational conditions so that seamless passenger transport is possible.

Criteria	Evaluation
Vessel	Very Good

The vessels are owned by different companies according to who operates which traffic line. Waxholmsbolaget, for example, owns 21 ships, 4 of which are used on the inner-city line 82. Waxholmsbolaget's fleet is very diverse with most of the ships having a capacity of ca. 350 passengers and some can carry up to 500 passengers. There is also an electric ferry in the fleet with a passenger capacity of 190 and a speed of 10 knots. 16 other ships on the SL lines belong to the respective line operators. For example, there are 3 ships on line 89 that are operated by Blidösundsbolaget AB. These 3 ships are replaced by an icebreaker ship when the waterway route is frozen.

On line 80 there are 11 vessels operated by Rederi AB Ballerina, one of which is electrically powered. The operation of electric ships is a step forward, but there is still potential for further development in the range of the battery. Propulsion technologies are a controversial topic here. Many of SL's contracts with waterborne traffic line operators expire in 2026 and further tendering procedures need to be launched. To date, new tenders have stipulated that the IMO

Criteria	Evaluation
Vessel	**Very Good**

Tier III standard for ships must be achieved regarding sustainable standards. Specific forms of propulsion are not specified, as the operators themselves should decide on the most suitable solution. The chosen solutions are partly electric, but some ships in the fleet also run on HVO diesel (Hydrotreated Vegetable Oil). It remains to be seen which technical solution will prevail.

Together with Candela, SL is planning a pilot project that will start in 2024 to test passenger operations with the Candela P12 on the line 89. Candela is a company that has been researching and developing hydrofoil technology for electric motorboats since 2014. Its first model was the C-7, which went into series production in 2019. In 2023 the Candela P12 was launched on the market, which was no longer a pure motorboat but a passenger ship with a capacity of 30 seats. The Candela P12 operates at an efficient speed of 25 knots. This would mean a time reduction from 55 minutes to 30 minutes on route 89. This makes the line more attractive. It is estimated that this could increase passenger volumes fivefold. The hydrofoil technology makes it possible to reduce energy consumption by 90 %, which makes the use of electric propulsion significantly more efficient, even at high speeds. The only disadvantage is that hydrofoil technology cannot be used in winter conditions when waterways are frozen.

On the one hand, there is a large fleet that must meet high standards in terms of sustainability and accessibility for passengers with bicycles and disabilities through tendering procedures, and on the other hand, the use of innovative hydrofoil vessels from Candela is being trialled in Stockholm, which have great potential.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

The public transport administrator SL operates not only the ferry lines, but also other public transport services such as buses and trains. This means that the shipping lines are highly integrated into the rest of the public transport network. On line 80 from 20 ferry landing points overall, there are four access points to the underground and five access points to other rail services. On line 89 with overall five ferry landing stations, there is a transfer to the main railway. The SL ferries are also integrated into the fare system of the entire public transport network, which makes it possible to use season tickets for ferry trips. There is also access for bicycles at all stations and a connection to cycle routes. The high level of integration into the public transport network strengthens the accessibility and connectivity of ferry services.

Criteria	Evaluation
Competitive position	**Very Good**

The public transport administration has managed to have the ferry lines operated by different companies, which leads to better competition and contribute to efficient ferry services. The tendering procedures are transparent and provide incentives to increase customer satisfaction. In competition of ferry transport with different modes of transport, there are both

Criteria	Evaluation
Competitive position	**Very Good**

substitutive and complementary effects. The close integration of the urban ferry lines lowers boarding thresholds and can lead to a gain in passengers who can easily switch between bus, train and boat. Those factors can be considered as complementary effects. Moreover, there is a recreational value of ferry services.

However, there is intermodal competition for some ferry services. Between different modes of transport cost figures determine competitional positions. For all public transport in the Stockholm region, the funding ratio is 50 % own revenue and 50 % tax funding. However, this ratio varies between different modes of transport.

The archipelago and urban ferry lines perform the worst with approx. 20 % for the archipelago ferries and approx. 10 % for the urban ferry lines. Low-cost recovery ratios often occur in passenger ferry services, as this is a costly mode of transport that often offers important transport connections that cannot be provided by other modes of transport. In comparison, the cost per person kilometre is 14 kroner (approx. €1.90) for the urban ferry lines, 4 kroner (approx. €0.55) for the bus and 2 kroner (€0.27) for the metro. The ferry cost sets up of fuel cost (41%), staff cost (30%), vessel cost (21%) and other costs (8%). This is precisely where Candela's new type of vessel can achieve cost reductions. With a 90% reduction in energy consumption thanks to hydrofoil technology, energy costs are reduced. At the same time, the speed can be increased, which makes the ship connection more attractive. A five-fold increase in passenger volumes can be expected. This leads to a more efficient utilisation of passenger capacity and thus also to a reduction in the passenger kilometre cost. At the same time, the Candela P12 promises a reduction in maintenance costs, since for example drive units are interchangeable. This shows potential to increase the competitive position of ferry passenger transport overall.

Criteria	Evaluation
Business model	**Very Good**

As a provider of local public transport, SL has a public service obligation to offer affordable transport connections for every citizen. This is among others done by ferry. The ferry lines offered have different operators such as Rederi AB Ballerina on line 80, Djurgårdens Färjetrafik AB on line 82 and Blidösundsbolaget AB on line 89. The operators are recruited through tender procedures for each ferry line, where the ferry operation, vessel operation and adjacent services are regulated. In addition, an incentive or penalty may be included to achieve a certain level of customer satisfaction, which is estimated in customer surveys. The contract reimbursement models may vary slightly but do normally consist of production and fuel payment per operational hour or some payment for administrative and start-up costs. Ticket revenues go to the public transport administrator. The tendering procedures are the base for sustainable business models for shipping lines operating the services.

The use of the Candela P12 on route 89 in particular offers a great potential for reducing costs and increasing revenue through an increasing passenger demand.

3. Conclusion

The analysis of water passenger transport services in Stockholm provides valuable insights into the potentials and challenges of this type of transport service. Waterborne passenger transport services are not only essential for connecting the islands in the archipelago, but also play an important role in

urban transport and contribute to making the city attractive. Both leisure passengers and commuters benefit from this transport service.

An important success factor is the integration of the ferry services into the overall public transport network. In Stockholm, ferry services are closely linked to other public transport modes such as buses and trains within the public transport network, providing passengers with seamless travel options and facilitating the use of waterborne transport. Another success factor is transparent and competitive tendering procedures for ferry service operators, which are the base for sustainable business models and in which environmental and service standards are set. Municipalities are here key actors as they determine the service level and financing as well as environmental and service quality standards. These procedures allow different companies to be involved, which increases the diversity of services and promotes competition. Common for ferry services is the usage of ferry lines for touristic and leisure trips. This adds another value to those services and is also relevant in Stockholm. At the same time touristic and leisure trips contribute to seasonal fluctuations in demand, which can lead to temporal overcapacities. This is one challenge for passenger services. Adapting services to these fluctuations requires flexibility and efficient utilisation of resources. The introduction of innovative technologies such as hydrofoil-based vessels like the Candela P12 offers great potential to increase the efficiency and attractiveness of waterborne passenger transport. This technology enables a significant reduction in energy consumption and operating costs as well as faster passenger transport.

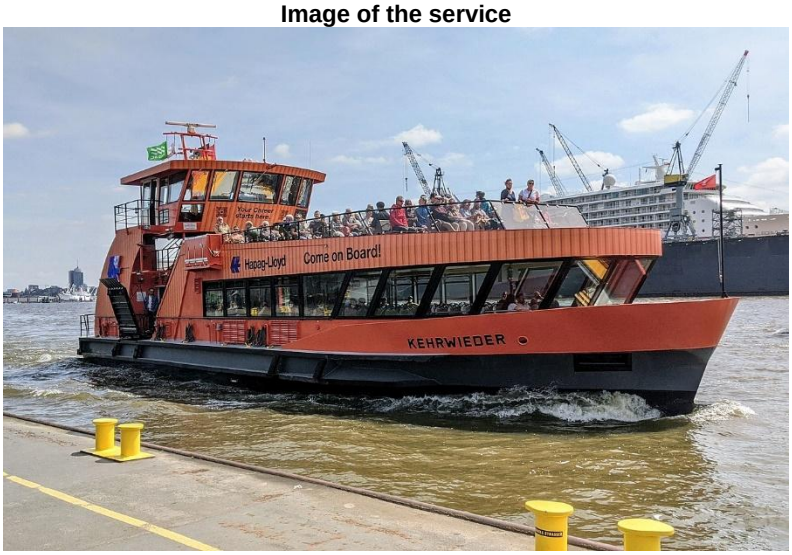
At the same time, the smaller scale allows for a more flexible schedule, allowing the service to adapt to transport demands more easily and therefore reducing underutilized capacities. This could help to make waterborne passenger transport more efficient and attractive not only in Stockholm but also in other cities and open up new areas of application. With its pilot project, Stockholm can become a pioneer of a future new development in how to operate waterborne passenger services.

HADAG – Waterborne Passenger Transport in Hamburg

1. Introduction

The HADAG Seetouristik and Fährservice AG (HADAG), which belongs to the local public transport service provider in Hamburg Hamburger Hochbahn AG (HHA), is the operator of the ferry lines in Hamburg. Its network consists of 8 lines is linked to the other transport modes as bus, rail and underground transport lines and is part of the Hamburg Transport Association (HVV) transport tariff system, which enables a seamless transition between other modes of transport with the same ticket prices. The location in Hamburg, with its harbour and metropolis of millions, contributes to scaling up the ferry service. HADAG has a long tradition dating back to 1888, the year it was founded.

Image of the service



HADAG ferry “Kehrwieder” at the Altona pier 2022 (Source Wikipedia)

Key Facts			
Name of service	HADAG	Crew	1 crew member per ship (ca. 120 employees)
Operator	HADAG, Hamburg Port Authority (HPA) Operator for Pontons	Automation	No Automation
Market Segment	Passenger Transport	Port equipment	Pontons
Region	East-West	Last Mile Transport	Integration into the public transport routes of the HVV
Status	Operational	Return Flows	Not relevant
Launch year	1888	Waterway infrastructure (Navigation Conditions)	Tidal waterway, no other limitations
Ferry Capacity	114-250 Passengers	Service frequency	8 Lines (15 min up to 1 h frequency)
Fleet Size	26	Transport volume	8 Mio Passengers in 2023
Ship Length	24.92 – 29.95 m	Societal benefits (e.g. mitigated emission)	Offer of additional transport connections, avoiding car traffic

Key Facts			
Draught	1.4 - 1.9 m (no limitation)	Supportive regulatory framework	One-man operation of the ships as harbour vessels, deadline adjustments for tenders
Propulsion	Diesel	Financial support	Funding by the City of Hamburg (public service obligation)
Equipment	Technical redundancies and camera supported 360-degree view for one man operation of gangway		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**

As a subsidiary of Hamburger Hochbahn AG, HADAG is publicly commissioned by the Hamburg Senate to ensure waterborne passenger transport in the area of the Port of Hamburg. HADAG's public service obligation is based on this commission. In this context, an operating task of the Senate ensures that new tenders for this service must be issued less frequently. This limits the time for new tenders to 15 years, which reduces the bureaucratic burden. In addition, the Hamburg Ports Authority argues that HADAG's passenger ships are also necessary in the event of an evacuation of the port.

To ensure that HADAG's ships can operate as one-man operations, the ships are not listed as inland waterway vessels, but as harbour ships. In addition, technical redundancies, and camera systems for a 360-degree view are necessary to ensure safety of one-man operation. All of these regulations help to make urban ferry transport possible. The only obstacle is the sector contracting law. Hamburger Hochbahn AG, for example, is a sector client for rail and bus operations, which allows for more flexible tendering and authorisation processes with higher tolerance limits. Waterborne public transport providers do not have this regulation, which makes the authorisation of orders such as repairs or the purchase of spare parts much more difficult, since ship repairs often are quite expensive and thus require extra tender processes.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

More than 8 million passengers use HADAG's services every year. This is divided between tourists and commuters. Even during COVID pandemic, 5 million passengers still travelled on HADAG ships in 2021, despite the limited tourism in Hamburg. Before the pandemic, the

Criteria	Evaluation
Cargo/passenger flows	Very Good

passenger volume was 9.5 million. The ease of switching between bus, train and ferry makes the service particularly attractive for commuters. 8 ferry routes are operated. Various destinations for commuters are targeted. These include, for example, the Airbus plants in Hamburg, which are served by route 62. In summer, there is often a particularly high-capacity utilisation here, as line 62 is very popular with tourists, too. To ease the strain on the line, the frequency should be reduced from 15 to 10 minutes. However, this has failed for the time being due to a lack of ships. Investments in ships are expensive and tendering procedures for them can be challenged and thus delayed. This makes further scaling of the service difficult. However, scaling to lower demand in winter is possible by adjusting the timetable. In the end, the service is already well adapted to the high demand.

Criteria	Evaluation
Infrastructure	Very Good

A particular challenge for the infrastructure in Hamburg is posed by the tide, which requires a certain degree of flexibility when transferring passengers. This flexibility is ensured by pontoons that float on the water and thus adapt to the tide. The pontoons are operated by the Hamburg Port Authority and are also available to other companies for a usage fee. In addition to passenger transfer facilities, mooring points are important where ships can stop after closing time. For this purpose, HADAG has several pontoons with 21 berths in the centre of Hamburg, which serve as operating areas. Several other berths are located remote. Other requirements for an existing infrastructure include the refuelling of ships and the disposal of ship waste and waste oil. Such services are offered in the Port of Hamburg. All the necessary infrastructure conditions are available on site showcasing good conditions.

Criteria	Evaluation
Vessel	Good

HADAG has a fleet of 26 ships. The ships are diverse and were put in operation between 1962 and 2018. The capacity ranges from 114 to 250 passengers. With 13 ships, the type 2000, which was built by Hamburg shipyards between 1997 and 2013, is the most common. This ship type can transport up to 250 passengers. It is powered by two diesel engines with an output of 283 to 331 kW. The ships are specially adapted for urban passenger transport. In particular, technical adjustments have been made to ensure safe one-man operation. This required the installation of technical redundancies, cameras for a 360-degree all-round view and also the installation of an automatic gangway that extends at the push of a button when docking. However, for legal safety reasons, single-person operation limits the number of passengers that can be carried. Without this restriction, the boats could carry more passengers. All ships are previously powered by diesel engines. Electrification of the fleet will be necessary in future. Under ideal conditions, it would be possible to electrify the fleet by 2038. This would require financial support from the City of Hamburg, a smooth process in the tendering procedures without disputes and a sufficient infrastructure for loading electric boats. HADAG has ordered three new ships from the SET shipyard in 2019. Due to an objection in the tendering process, the start of construction of the ships has been delayed. These are plug-in hybrid battery-powered ships with diesel range extenders. HADAG operates a large

Criteria	Evaluation
Vessel	Good
fleet that is customised to the requirements of passenger transport. In the future, however, there will certainly be further investments to electrify the fleet.	

Criteria	Evaluation
Logistics/Coordination	Very Good
The 8 routes operated by HADAG are scheduled in intervals of 15 minutes up to an hour. The HVV is the transport and tariff association in Hamburg to which HADAG also belongs. This means that ferry transport is integrated into the local public transport concept, and it is possible to change from ferry terminals to bus or underground stations. All these modes of transport are integrated into a tariff network and can be used with the same ticket. The best example of this is the “St. Pauli Landungsbrücken” station, where several ferries run together, and it is possible to change at a bus station or an underground/suburban railway station. In order to increase the connection of local transport to other modes of transport, the HVV has published the HVV Switch App, which also displays routes with rental bikes and other offers. To this end, HVV is working together with MOIA, Sixt, Miles and TIER. This provides a high degree of logistical connectivity for ferry transport in Hamburg. There are also a bicycle rental stations connected to ferry routes.	

Criteria	Evaluation
Competitive position	Good
When selecting routes, the HVV makes sure that ferry transport functions as a complement to other modes of transport and offers a mobility service that can only be offered with a delay due to detours over bridges on other modes of transport. This means that the ferry service can offer a faster connection due to the shorter waterway connection. This also helps to reduce motorised private transport and through a modal shift of commuter traffic to local public transport. Unfortunately, the disadvantage of ferry transport is the relatively high cost. The price per passenger kilometre is higher than by bus. But despite the requirement for high investments in ships and mooring points as well as the high operational costs, ferry transport created an added value improving the connectivity of public transportation by offering connections which cannot be offered by other modes of transport in the same quality due to a lack of tunnels or bridges or other restrictions.	

Criteria	Evaluation
Business model	Good
The business case for HADAG results from the public service obligation imposed by the Hamburg Senate. This is stipulated by the Senate, as ferry transport represents a valuable	

Criteria	Evaluation
Business model	**Good**
extension of the public mobility offer for Hamburg with the Elbe River, which is also used by many commuters.	

3. Conclusion

The HADAG provides a well-established example of waterborne passenger transportation and there is even more potential within Hamburg. There are still plans to increase the frequency on individual routes in the future. It is also conceivable that additional stops will be offered, for example at the new “Elbtower” or the “Holthusenkanal” in the new “Hafencity” district. Hamburg has particularly favourable conditions for waterborne passenger transport. With the river Elbe, HADAG is able to offer transport services complementary to other modes. This example shows that the intermodal competition depends on the geographical situation that allows to use ships as superior mode for selected routes within the public transport network. At other locations where waterways have a less prominent role in the transportation network, or where detours can be minimised by bridges, it can be assumed that the complementary function of ferry transport is less important or non-existent. This requires a careful analysis for extension of the concept to other locations. To justify the high investments and cost the waterborne public transport has to offer an added value to the public mobility services. The case in Hamburg also showed that the right mix of leisure and commuter transport is important for the success of the service.

Waterbus

1. Introduction

The Waterbus Rotterdam-Drechtsteden is a significant aquatic public transportation service in the Netherlands, recognised for being the largest of its kind in the Netherlands. The service has been in operation for almost 20 years. It serves approximately 1.9 million passengers annually, offering routes between Rotterdam and historic Dordrecht, along with other destinations within the South Holland province. Notably, the Waterbus provides a direct connection to the UNESCO World Heritage Site Kinderdijk, a location famous for its iconic windmills, enhancing the accessibility and appeal of visiting this and other key attractions.

The service is operated by Blue Amigo since 2022. Before, Koninklijke Doeksen and Arriva Nederland operated the service between 2010 and 2022. The Waterbus system includes a fleet of fourteen ships, making stops at twenty-one locations along vital waterways connecting Rotterdam and Dordrecht, including the Maas and Merwede rivers. This network covering 21 stops facilitates not only daily commutes but also tourist visits to places like Kinderdijk, directly from Rotterdam or Dordrecht. With the largest ship in the fleet capable of carrying up to 150 passengers, the Waterbus emphasizes comfort, convenience, and accessibility, including provisions for bicycles to be brought on board free of charge.

The Waterbus operates year-round, with adjusted schedules for summer and winter to accommodate seasonal variations in passenger flow. Payment options are versatile, accommodating both the OV-chipkaart for regular commuters and e-tickets or bank cards for tourists and occasional riders. This inclusivity extends to pricing options designed to suit a range of needs, from single journey tickets today passes for unlimited travel within the region, ensuring that the Waterbus is an accessible option for both residents and visitors.

Image of the service

Showing a Waterbus passenger vessel (Source: Waterbus.nl)

The new operator of the Waterbus service since 2022, is transitioning towards zero-emission vessels. Initially, cleaner diesel (HVO) and temporary hybrid ships, which will eventually switch to fully electric, are being introduced. This fleet upgrade includes three electric ships for specific routes and six new

hybrid ships, enhancing sustainability. The aim is to achieve 100% sustainable and zero-emission operations within eight years, potentially incorporating battery or hydrogen technologies. This innovation aligns with the Clean Air Agreement goals, contributing to improved air quality in the region[16].

The Waterbus service has introduced the "Blue Hamburg," the first of its new electric vessels, marking a significant step towards sustainability and innovation in public water transport in the Rijnmond region. The fleet's expansion will include more electric catamarans and hybrid ships to serve various routes, including the longer connection between Rotterdam and Dordrecht. These modern vessels are designed to cater to diverse passenger needs, featuring improved accessibility, more space for bicycles, and enhanced onboard comfort with larger windows for panoramic views. This transition towards electric and hybrid technology underscores Waterbus's commitment to reducing emissions and promoting clean air, aligning with broader environmental goals.[17]

Key Facts			
Name of service	Waterbus	Crew	127 employees
Operator	Blue Amigo Waterborne Public Transport, part of the Aqualiner Group	Automation	None
Market Segment	Public transport	Port equipment	Docking quays
Region	Rotterdam-Dordrecht	Last Mile Transport	Integration into the public transport routes
Status	Operation	Return Flows	Not relevant
Launch year	1999	Waterway infrastructure (Navigation Conditions)	Rhine (Maas)
Ferry Capacity	Differs per vessel	Service frequency	Several times daily
Fleet Size	14 vessels	Transport volume	1.9 million passengers/y
Ship Length	Multiple vessels	Societal benefits (e.g. mitigated emission)	Traffic congestion relief and sustainable urban mobility.
Draught	Multiple (catamaran)	Supportive regulatory framework	No special framework
Propulsion	HVO and Electricity	Financial support	Concession for public transport
Equipment	No special equipment needed		

2. Evaluation Criteria

Criteria	**Evaluation**
Administrative Requirements	**Very Good**
For the Waterbus service several relevant aspects come into play regarding the administrative framework. Most of them are standard as they are required for inland waterway transport services in general.	

[16] https://www.schoneluchtakkoord.nl/actueel/nieuws-schone-lucht-akkoord/binnenvaart/schonere-schepen-waterbus-tussen-rotterdam/

[17] https://www.waterbus.nl/nieuws/dit-zijn-ze-dan-de-langverwachte-elektrische-nieuwe-waterbussen

Criteria	Evaluation
Administrative Requirements	**Very Good**

Specific navigation rules may apply to the Waterbus service, including speed limits and other navigational safety measures that must be adhered to. Moreover, gaining access to and using quays for passenger boarding and disembarking involves administrative procedures. This may include negotiations with port authorities or municipalities for space allocation and usage rights. The adoption of new and sustainable technologies, such as biofuels and electric vessels, necessitates regulatory approval. This process includes ensuring that all equipment meets safety and environmental standards.

To optimize the Waterbus service's administrative requirement criteria, it's essential to work closely with regulatory bodies, port authorities, and other stakeholders. This collaboration can help streamline the approval process, ensure compliance with all regulations, and ultimately support the efficient and sustainable operation of the Waterbus service.

Criteria	Evaluation
Cargo/passenger flows	**Very Good**

The passenger volume of 1.9 million passengers per year for the Waterbus service reflects its ability to meet the transportation needs of commuters and tourists within the urban and short-range segments it serves.

The Waterbus operates in densely populated urban areas, connecting key locations in Rotterdam, Dordrecht, and the Drechtsteden region. These areas exhibit substantial transport demand due to their economic, cultural, and residential significance. The Waterbus's success in these urban environments indicates a strong proof of concept, showcasing its essential role in the local transport ecosystem. It is planned to add destinations and enhance services, including a special summer route, the Haringvliet Expedition.

The service primarily covers short to medium distances, ideal for daily commuting and tourist excursions. This aligns perfectly with the transport demand for efficient, scenic, and convenient travel options over water, differentiating it from traditional road or rail transport. It is designed to accommodate the frequencies required for efficiency. With services running at regular intervals and has the capacity to adjust based on seasonal demand, it efficiently meets the needs of both regular commuters and the tourist population.

The Waterbus demonstrates considerable flexibility in handling transport capacity, adapting its services to peak tourist seasons and regular commuter traffic. The introduction of new vessels and the expansion of routes, as discussed, are testament to its adaptability and responsiveness to varying demand levels.

The service consistently meets and adapts to the high demand in urban and short-range segments, effectively serving a broad user base. It aligns well with the specific transport needs of its service area, offering reliable, scenic, and direct connections between key urban locations and attractions. These factors contribute to the high passenger volume and utilisation of services.

Criteria	Evaluation
Cargo/passenger flows	Very Good

The strategic expansion of routes and the fleet demonstrates the service's commitment to meeting evolving demand.

Criteria	Evaluation
Infrastructure	Very Good

The Waterbus operates in the Rotterdam-Drechtsteden area, characterized by its well-maintained, wide waterways with sufficient draft. These conditions are conducive to the operation of larger vessels, allowing the Waterbus to utilize a fleet that is not constrained by the limitations often found in narrower and shallower urban waterways. This advantageous setting ensures that the Waterbus can maintain high operational efficiency and reliability, providing a consistent and dependable service to passengers. The available waterways are effectively used, ensuring accessibility, convenience, and efficiency for its passengers. This utilization of the area's favourable navigation conditions further contributes to the feasibility of the service and its positive impact on urban mobility.

The service's infrastructure must accommodate passenger boarding and disembarking efficiently, requiring dedicated quays and access points optimized for high foot traffic areas, especially in historic or densely populated urban areas. The service relies on fixed installations for passenger operations, such as dedicated quays and potentially mobile boarding equipment, to ensure accessibility and safety for all users.

The area's infrastructure supports the seamless integration of the Waterbus service, enhancing its effectiveness as a key component of urban mobility. The strategic use of the region's robust waterway infrastructure enables the Waterbus to offer a high level of service, capitalizing on the strengths of the existing public transportation network(s).

Criteria	Evaluation
Vessel	Very Good

The Waterbus fleet is specifically designed for operation along the waterways in the Rotterdam-Drechtsteden area. The wide and well-maintained waterways of the region allow the Waterbus to utilize vessels that are optimally sized for both the water conditions and the passenger demand, ensuring a high level of service efficiency and comfort. The selection of the Waterbus fleet considers the number of passengers (including bicycles), ensuring that vessels are adequately equipped to meet peak demand periods without sacrificing speed or convenience. This focus on passenger capacity is critical for maintaining high service levels, especially during tourist seasons.

The Waterbus fleet incorporates modern vessels with advanced equipment, potentially including a high level of automation. This approach aims to reduce operational costs and the need for extensive crew, contributing to overall operational efficiency keeping or improving the safety on board. The possibility of integrating autonomous vessel operation in the future could further strengthen the competitive position of the Waterbus service.

A proactive approach is followed to strengthen environmental sustainability. Propulsion and fuel concepts of the Waterbus fleet are aligned with environmental sustainability goals. The

Criteria	Evaluation
Vessel	**Very Good**

introduction of electric vessels and the consideration of alternative fuels reflect a commitment to reducing emissions and enhancing public acceptance, particularly important in the urban environment of the Rotterdam-Drechtsteden region.

The Waterbus service demonstrates flexibility in its fleet management strategy, balancing the efficiency of modern and possibly custom-designed vessels with the operational requirements. This strategic balance between innovation and flexibility facilitates the service's adaptability and responsiveness to changing market demands.

The Waterbus fleet exemplifies how advanced vessel design and management practices can significantly contribute to the successful implementation and operation of urban and short-range IWT services, making it a leading example in the sector.

Criteria	Evaluation
Logistics/Coordination	**Very Good**

The Waterbus service is designed to offer a seamless connection between key urban areas and destinations. This includes efficient scheduling, reliable service, and integration with other modes of transport (e.g., buses, trams, and bikes) to ensure passengers can easily reach their final destinations.

Boarding and alighting points are developed and optimised by strategically locating them as close as possible to passengers' origins and destinations, especially in urban environments, enhancing the service's operational efficiency. The strategic placement of stops and the integration with other transport modes demonstrate a well-coordinated approach to ensuring passengers have efficient access to last-mile solutions.

Advanced Solutions are used to strengthen operational efficiency. The Waterbus incorporates digital applications for ticketing and real-time service updates, streamlining the passenger experience and improving efficiency. Automated processes, such as online booking and check-in systems, further enhance operational efficiency and contribute to modern service delivery.

The Waterbus service potentially integrates additional value-added services, such as bike rentals at stops or partnerships with local tourist attractions, to strengthen the overall value proposition for passengers. This approach enhances the connectivity and attractiveness of the service.

Overall, the Waterbus offers a customised Passenger Experience. The service is tailored to meet the specific needs of its passengers, providing a high-performance transport solution that ensures seamless operation from origin to destination.

Criteria	Evaluation
Competitive position	**Good**

Comparing the Waterbus service to traditional public transport options like trains, buses, and metros, several key factors highlight its competitive position within urban and short-range passenger transport.

The Waterbus allows for the avoidance of traffic congestion. Unlike buses and, to some extent, metros and trains that can be affected by urban congestion and infrastructure limitations, the Waterbus operates on waterways that are typically free from such constraints. This can result in more reliable and often quicker transit times for certain routes. The Waterbus provides direct connections between key urban and touristic destinations that may not be as easily accessible by train, bus, or metro. Strategic urban connectivity is created by connecting key points of interest directly, which may not be as directly served by other modes of public transport. Its routes can offer unique and attractive journeys, enhancing the passenger experience beyond mere transportation. The Waterbus offers a unique and pleasant travel experience by offering scenic routes that are not susceptible to traffic congestion.

Trains and metros typically have higher passenger capacities than Waterbus vessels. However, the Waterbus's ability to bypass road traffic and offer relaxing, pleasant routes can be a significant draw for passengers, especially tourists. Additionally, water-based transport can sometimes provide better accessibility to areas not served by rail or metro networks. Further efficiency gains may be achieved by a potential shift to autonomous vessels.

While trains and metros are also efficient and relatively low in environmental impact, buses, especially those not yet electrified, can contribute to urban pollution and congestion. The Waterbus, particularly with its shift towards electric vessels, presents a greener alternative, aligning with increasing environmental consciousness among the public and policymakers.

Public transport systems are often subsidized due to their social benefits, which can affect their cost structure. The Waterbus, by offering substantial social benefits such as reduced congestion and emissions, may also be eligible for subsidies, potentially making it a cost-competitive option.

The Waterbus service complements the public transport system by providing a unique, efficient, and enjoyable mode of transportation that stands out for its operational reliability, environmental benefits, and contribution to enhancing urban "liveability".

Criteria	Evaluation
Business model	**Good**

The Waterbus' business model is recently evaluated within the "Transitieplan Waterbus" document[18], focusing on sustainability and the financial feasibility of inland waterway transport (IWT) operations.

[18] https://www.bing.com/ck/a?!&&p=784932ac2e2a7e37JmltdHM9MTcwNzY5NjAwMCZpZ3VpZD0zYmExODg5OS02OTNlLTZlOWQtM2IwNC05YTUzNjg2OTZmMTQmaW5zaWQ9NTE5Mw&ptn=3&ver=2&hsh=3&fclid=3ba18899-693e-6e9d-3b04-9a5368696f14&psq=transitieplan+waterbus&u=a1aHR0cHM6Ly93d3cuenVpZC1ob2xsYW5kLm5sL3B1Ymxpc2gvYmVzbHVpdGVuYXR0YWNobWVudHMvdHJhbnNpdGllcGxhbi1wZXJzb25lbnZlcnZvZXItb3Zlci13YXRlci90cmFuc2l0aWVwbGFuLXdhdGVyYnVzLnBkZg&ntb=1

Criteria	Evaluation
Business model	**Good**

Key elements include public funding, subsidies, revenue generation to cover operational and capital costs, and start-up investments. The model benefits from strategic actions like introducing new ships, creating marketing plans, and adding new stops to increase passenger volume. Additionally, cost-saving measures and potential subsidies are identified as crucial for financial stability. The commitment to not scaling down services but focusing on growth through convenience and accessibility enhancement signifies a robust approach toward achieving a sustainable business model.

Recognising the social and environmental benefits of reducing road traffic and emissions, the Waterbus business model incorporates public funding (concession) and subsidies. These financial supports are crucial for offsetting the initial start-up investments and operational costs, making the service more complementary to and competitive against traditional road- and rail-based public transport.

The business model is structured around generating sufficient revenues to cover both capital and operational expenses. Revenue streams include passenger ticket sales, concessions, and potentially partnerships with local businesses and tourist attractions. The competitive position of the Waterbus, leveraging its unique offering and convenience, plays a significant role in attracting and retaining passengers. The Waterbus service is aligned with public policies aiming for a modal shift from road to water, enhanced by the environmental benefits of the service.

A focus is on cost-saving measures, such as the introduction of new, more efficient vessels (including hybrid and electric ships), and strategic marketing efforts to increase passenger volumes. Operational efficiencies are sought through the optimization of routes and schedules to match passenger demand, reducing variable costs.

The model emphasizes the importance of collaboration with various stakeholders, including local governments, port authorities, and the community. These relationships are vital for the expansion of services, such as the development of new stops and enhancing accessibility, which directly contribute to the growth of the passenger base. Key stakeholders include the Province of South Holland, the Drechtsteden, the Municipality of Rotterdam, and the Port of Rotterdam Authority. There is a strong stakeholder commitment which allows for the anticipation of cost-covering revenues.

Required start-up investments are directed towards building a modern, environmentally friendly future proof fleet and developing the necessary infrastructure, such as docking stations. These investments are critical for ensuring the long-term sustainability and attractiveness of the service. The business model also considers the role of digitalization and potential automation in enhancing operational efficiency and passenger experience. This includes online ticketing, real-time tracking of vessels, and exploring autonomous vessel technology to reduce operational costs in the future. The innovative approach to leveraging technology and efficient fleet management to ensure operational efficiency and attract passengers.
Given the strategies and the supportive context provided by public funding and an increasing societal preference for sustainable transport options, the Waterbus business model

Criteria	Evaluation
Business model	**Good**
demonstrates a comprehensive approach to establishing a competitive, sustainable, and financially viable urban and short-range passenger transport service, positioning it strongly for future growth and adaptation to emerging transport and environmental challenges.	

3. Conclusion

The analysis shows several good practices and lessons learnt which contribute to the successful operation of the Waterbus service. The Waterbus is effectively integrated with existing cycling, touristic and public transport networks, which enhances overall mobility and accessibility. The service supports the regional development. It contributes to spatial and economic development, as well as sustainability, highlighting the role of transport in broader regional strategies. Beyond transportation, the service enhances social and cultural connections across areas, supports specific developments, and attracts tourism and recreation. Considering the community and economic benefits, successful operation involves close cooperation between different governing bodies, transport providers, and other market parties, ensuring that the service meets the diverse needs of the region.

The good service quality contributes to high passenger satisfaction. The service is highly valued by travellers, indicating the importance of reliability, convenience, and user experience in public transport. Innovation and sustainability are high on the agenda. Emphasizing cleaner, more sustainable transport options not only address environmental concerns but also positions the service as a forward-thinking component of the urban mobility landscape.

Learning from the Waterbus service key success factors for the development of water-based public transport systems are:

- Stakeholder Collaboration
- Community Engagement
- Flexibility and Scalability
- Leverage Technology
- Evaluation and Adaptation

By adopting these practices and lessons, regions in Europe can develop water-based public transport systems that are sustainable, efficient, and well-integrated into the broader transport network, contributing to the overall mobility, accessibility, and liveability of urban areas.

Mahart – BKK Boat Service

1. Introduction

The service was launched in 2013. It is part of the public transport system in Budapest. As of 2023, Mahart has extended the Danube cruise service's timetable in Budapest until 29 October. The Budapest Circular Route offers a unique way to admire the city's landmarks and the Danube's stunning panorama. The ferry service operates between the National Theatre and Margaret Island, covering a route with the city's highlights.

On Thursday and Friday, passengers with a valid Budapest monthly pass or a longer valid pass can board the boat service in Budapest for free. This includes both paper-based Budapest passes, and digital passes purchased through BudapestGO. However, these discounts do not apply on Saturdays and Sundays or for individuals without a Budapest pass. On weekends, an adult day ticket for boats costs HUF 1500 (approx. 4 EUR), and children under the age of seven can travel for free. There is an additional fee of HUF 1000 (approx. 2,60 EUR) for transporting dogs and bicycles. The ticket allows unlimited travel on the day of validity.

Image of the service

Budapest passenger vessel (Source: https://privatbankar.hu/cikkek/kozerdeku/uj-allomasai-vannak-a-bkk-hajonak-306684.html)

Key Facts			
Name of service	Passenger Transportation	Crew	1-2
Operator	BKK/Mahart	Automation	No Automation
Market Segment	Transport facility for locals & tourists alike	Port equipment	Piers or pontoons are available in Budapest
Region	Danube (Budapest, Hungary)	Last Mile Transport	Integration into the public transport tariffs of BKK
Status	In operation	Return Flows	Not relevant

Key Facts			
Launch year	2013	Waterway infrastructure (Navigation Conditions)	No navigational limitations
Ferry Capacity	140	Service frequency	4 ferry lines with up to 2 rotations per hour Tuesday to Sunday[19]
Fleet Size	-	Transport volume	No figures accessible
Ship Length	-	Societal benefits (e.g., mitigated emission)	Sustainable public transport with focus on touristic passengers
Draught	No relevant draught limitations	Supportive regulatory framework	None
Propulsion	Diesel	Financial support	Service is part of BKK public transport
Equipment	On-board Wi-Fi		

2. Evaluation Criteria

Criteria	Evaluation
Administrative Requirements	**Very Good**
There are no special administrative requirements neither facilitating, nor hampering the service. The public transport company has the respective lines in its portfolio and selects a provider for the service in a public tendering procedure. This procedure complies with the usual regulatory requirements and does not require any additional effort.	

Criteria	Evaluation
Cargo/passenger flows	**Average**
The current service is integrated in the local public transport network, but the touristic/leisure value dominates. However, if the route is amended to north and south suburban cities and/or more modern vessels would be put in service, it might be more attractive for commuters as public transport service. Discussions are on-going regarding the service and its extension among stakeholders.	

Criteria	Evaluation
Infrastructure	**Good**
The integration of the ships into the public passenger transport system proved to be effective. A notable fact is that no additional infrastructure was required for the implementation of this service, as existing jetties and pontoons could be utilised. This not only led to significant cost savings, but also helped to reduce the environmental footprint. In most of the cases the navigational conditions in Budapest do not limit the service. However, during low water situations not all stations can be called due to the very steep ramp.	

[19] Source: https://hungarytoday.hu/budapest-boat-service-bkk-danube-public-transport/, last access 8th of April 2024

Criteria	Evaluation
Vessel	Good

The ships used for the service are older models. This does not represent a disadvantage for the existing service. On the one hand, the use of older ships can save setup costs. On the other hand, older passenger ships have a certain touristic added value, with a nostalgic experience. However, if the service is expanded, the purchase of modern ships will be necessary to enable the operation of commuter routes. The investment costs required here must be in relation to the added value they provide through better connections for commuters. This added value can be provided by connecting suburban areas. The vessel can showcase advantageous conditions, as they are adapted to the needs of tourist transport.

Criteria	Evaluation
Logistics/Coordination	Good

The service is integrated into the operator's (BKK) public transport network in Budapest. The same price conditions apply to the ferry service as for other modes of transport. This has the disadvantage that the service has no price autonomy over the ferry routes it offers. However, the advantage of increased multimodal accessibility outweighs this, allowing passengers to switch between different modes of public transport. Integration into the local public transport system also increases price transparency for tourists and thus lowers access barriers.

Criteria	Evaluation
Competitive position	Good

There is no further competition in waterborne passenger transport within the public transport system, as the service is the only provider here. However, various touristic services which are not part of the public transport system are offered. In intermodal competition, passenger shipping is very popular with tourists and allows them to admire many important tourist attractions from the Danube. In commuter transport, on the other hand, the service does not achieve a position in which it can offer a faster connection compared to bus and rail or create additional connections for commuter traffic. The added value of the service is exclusively for recreational transport. The operation of older ship types is sufficient for this. Acquisition costs would be necessary to expand the service to better connect commuter traffic. Therefore, the service finds a niche in recreational transport, which represents a profit for the city of Budapest, which can thus be covered cost-effectively.

Criteria	Evaluation
Business model	Good

The waterborne passenger transport is financed by the public transport operator BKK in Budapest. BKK put this service out to tender. The contract was awarded to a company, which

Criteria	Evaluation
Business model	**Good**
also offers various touristic services on the Danube. The service complements the tourist offer within the city. The integration into the public transport price system offers a low-threshold changeover to the waterborne mode of transport and provides price transparency for tourists.	

3. Conclusion

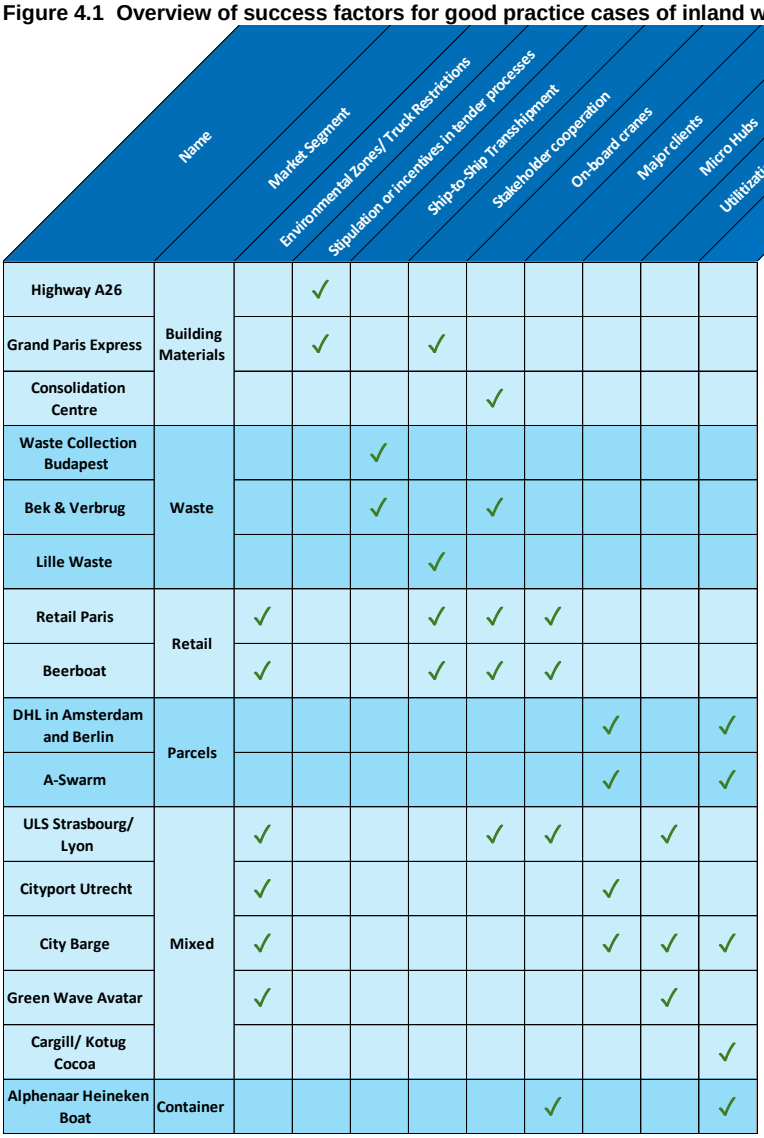
The service itself is considered as a prestigious one in the portfolio of the public transport company, however, it does not offer a major added value for the every-day users of the public transport services. Throughout the years it became rather a very nice touristic destination / service. Tourists purchasing different types of tickets for their stays in Budapest have been using the ships as they can combine their travels in the city with a special one with an excellent view.

Budapest is a unique city having the Danube in its middle, thus rolling out the service in other cities as part of the public transportation does require waterways. In Budapest, the waterborne public transport service might be extended by including sub-urban stops. Thus, the line could connect cities North and South of Budapest with downtown Budapest. This could contribute to modal shift of passengers from car to ferry service. This would significantly contribute to the reduction of emissions and congestion. However, the extension would require faster vessels than the ones currently used. Discussions are on-going regarding the service and its extension among stakeholders.

4 Lessons learnt from the Good Practice Case Evaluations

In an analysis of 20 good practice case studies, the integration of inland waterway transport into urban and short-range logistics was examined in various areas. These good practice case studies provide valuable insights into the success factors, challenges and replicability of such projects. The following chapter outlines the key success factors and challenges that emerge from the analysis of the 20 good practice examples. These success factors and challenges are crucial for the successful integration of inland waterway transport into urban and short-distance freight logistics and passenger transport. By analysing these factors, patterns can be identified, and recommendations derived that can help other cities and regions to successfully implement similar projects. Furthermore, an assessment can be made, about which are the key determinants for estimations of market potentials in subtask 2.3.

Figure 4.1 Overview of success factors for good practice cases of inland waterway freight transport



Name	Market Segment	Environmental Zones/ Truck Restrictions	Stipulation or incentives in tender processes	Ship-to-Ship Transshipment	Stakeholder cooperation	On-board cranes	Major clients	Micro Hubs	Utilitization of return ways	Zero Emission
Highway A26	Building Materials		✓							
Grand Paris Express			✓		✓					
Consolidation Centre						✓				
Waste Collection Budapest	Waste			✓						
Bek & Verbrug				✓		✓				
Lille Waste					✓					
Retail Paris	Retail	✓			✓	✓	✓			
Beerboat		✓			✓	✓	✓			
DHL in Amsterdam and Berlin	Parcels							✓		✓
A-Swarm								✓		✓
ULS Strasbourg/ Lyon	Mixed	✓				✓	✓		✓	
Cityport Utrecht		✓						✓		
City Barge		✓						✓	✓	✓
Green Wave Avatar		✓							✓	
Cargill/ Kotug Cocoa										✓
Alphenaar Heineken Boat	Container						✓			✓

Various success factors and challenges apply in the different categories of good practice cases. **Figure 4.1** provides an overview of the distribution of success factors according to good practice cases. Only a selection of the most relevant success factors is shown in the figure. Further success factors that apply in individual cases can be found in this chapter and in the good practice case analyses. Regarding success factors a significant distinction must be made between freight and passenger cases.

One overarching success factor is the **density of waterways** as well as the proximity of waterways to densely populated areas that enhance the potential for IWT. Urban waterborne logistics and passenger transport are only possible in cities with waterways. The density of the urban waterway network determines the local waterborne transport options. Dependent on the transport route and logistic concept a single route or an urban/short-range network is operated on waterways. Waterways usually run through the heart of the cities so that densely populated areas are well served by waterways. Waterways with its ample capacities may allow to better reach city centres for urban deliveries and commuters by barge. Waterborne transport contributes to the mitigation of transport emissions and the damage to road networks in cities. In cities without dense waterway network, an efficient last mile concept is required to implement urban IWT.

Another factor that can lead to the success of urban and short-range IWT solutions is **co-operation with relevant stakeholders**. The implementation of round tables with stakeholders from various

market segments to discuss requirements and develop tailored solutions for urban waterway logistics facilitate the creation of public acceptance. The involvement of public stakeholders such as city governments and authorities help to get commitment and support. This can lead to help with other challenges, such as the development of transshipment sites or the creation of regulatory frameworks. Municipalities and public interest groups can thus work positively towards the provision of sustainable transport concepts that can be integrated as a building block of modern sustainable urban development, both around public passenger transport and in the distribution of goods for urban supply. In urban passenger transport, the cooperation with public stakeholders is essential with respect to the implementation of the service as public service obligation and the integration in public transport networks.

4.1 Success Factors and Challenges in urban and short-range freight transport

The **feasibility** of urban and short-range IWT is challenging. Technological developments as regards automation and digitization are a driver to strengthen urban and short-range IWT concepts. These developments can strengthen the performance and efficiency of services. As regards competition the willingness to pay a surcharge for urban IWT compared with truck logistic increases. However, the cost competitiveness of urban and short-range IWT remains challenging considering shorter distances, smaller transport volumes and navigation conditions. Economies of scale can only be realised to a limited extent compared with traditional IWT markets. Therefore, this market segment requires smart concepts for feasible operation. The market development relies strongly on research activities as customised solutions/concepts are required. Therefore, it is important to foster research activities such as the establishment of living labs to try out concepts in real-life.

The establishment of a sustainable business model for urban and short-range IWT services requires a convincing concept addressing logistic requirement with a competitive IWT concept. This includes solutions to reduce risks of investors to an acceptable level to allow for required investment as the fragmentation of the IWT market limits the investment capabilities. In the start-up phase public funding may be required considering the strong competition from truck transport and the challenging feasibility of IWT services. As the development could take time for the sustainable implementation follow-up funding could be needed. Depending on the societal gains associated with the service this may be advantageous from a social point of view. Apart from financial support, market development activities by authorities and ports can be a supporting factor. For instance, VNF supports the development of IWT in France and Haropa Ports contributes to the development of urban IWT concepts. Societal gains resulting from the substitution of truck transport by waterborne logistic concepts are a socioeconomic benefit resulting from the public support.

Restrictions for truck operation are an important factor for the competitiveness of urban and short-range IWT. Considering congested road networks, noise annoyance due to truck traffic and regulatory restrictions in urban areas and beyond good practice cases demonstrate that waterborne transport could provide a reliable logistic solution at competitive cost. **Environmental zones** are one success factor, which applies to several good practice cases for freight transport. This especially applies to the implementation of environmental zones and other regulatory restrictions that limit the access to inner cities for truck transport, which improve the competitive situation and must be seen as one of the key success factors overall. This competitive advantage is strengthened when IWT services can utilise **zero emission technologies** such as electric barges, as has been shown here

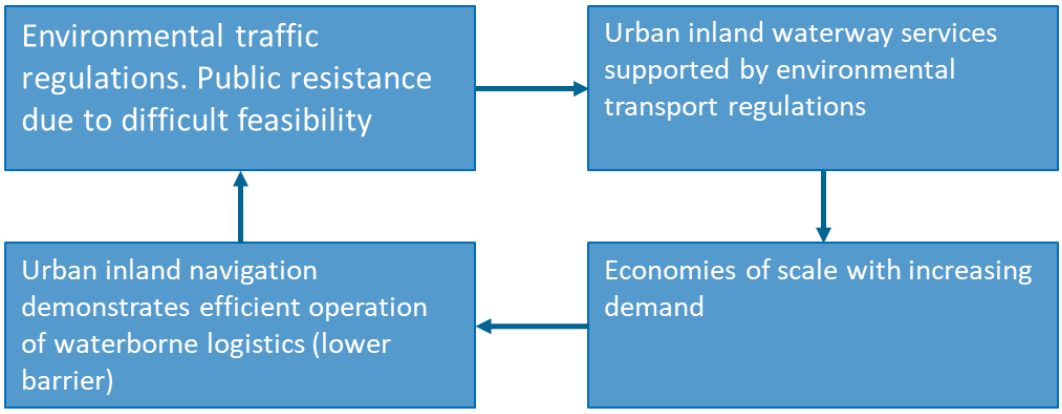
in some cases. The propulsion technology of the vessels needs to be compatible with local requirements and should be ready for long-term use. This is relevant for urban operation.

The restrictions for truck traffic are one of the regulatory instruments that municipalities and cities can use to promote their own sustainability locally. In many cities, however, such regulatory measures are met with scepticism by the population, as local businesses and shops can be negatively affected by such restrictions if this also restricts deliveries to these businesses and shops. This is why alternative modes of transport are needed which, on the one hand, fulfil the framework of regulatory restrictions and enable sustainable transport and, on the other hand, can fulfil the transport function of truck transport and the urban supply. This creates demand for alternative solutions in urban logistics such as IWT.

The good practice cases, such as those of ULS, the Green Wave Boat or the Citybarge project, clearly show the feasibility of urban logistics that, despite the limitations for inner-city truck traffic, fulfil the necessary functions and increase the operational efficiency of urban spaces despite environmental protection. This feasibility can strengthen the political enforceability of emission zones and other regulatory traffic restrictions in the future, as the implementation of low emission zones does not lead to a deterioration in the connection of affected shops and businesses to the goods distribution network, if alternative waterborne transport service can be offered and even can improve the quality of life through a reduction in heavy goods road traffic in urban areas. Increased support for low emission zones, in turn, would again have a positive competitive effect, resulting in a self-reinforcing effect that would drive the transformation forward. Figure 4.2 illustrates this connection.

To achieve this self-reinforcing effect, two conditions must be met. The first condition is an increase in the quality and the price-performance ratio of the waterborne transport service compared to the transport service operated by trucks. Here, the existing delta must be reduced to convince public stakeholders and strengthen the public support for environmental zones. The other condition is to communicate the advantages of waterborne transport. Various actors are required to fulfil both conditions, including the operators of transport services that use the waterway as a mode of transport, as well as stakeholders who benefit from sustainable transport and are interested in promoting it.

Figure 4.2 - Urban IWT and environmental zones



Acquisition of **major customers** is of particular importance. GEODIS is an important customer for ULS in Strasbourg, as well Heineken for the case of the Alphenaar boat. Large customers help to achieve capacity utilisation of the transport service due to stable and high transport demands. Major costumer acquisitions also help to create a transport service that is efficiently adapted to the transport demand, because demand from large customers can more easily be anticipated. However, the acquisition of major customers also drives the transformation of logistics networks towards sustainable modes of transport and favours the integration of inland navigation as a standardised

logistics concept that can be used as a combinable solution to various problems and needs in urban areas. Standardisation can be achieved through multiple aspects such as the uniform use of standardised loading units specifically adapted to small scale solutions for urban transshipments.

A **smart logistic concept** adapted to local conditions contributes to the success of urban and short-range IWT. The seamless coordination of barge operation, transshipment and last mile operation strengthen the performance. The use of standardised loading units may enhance the logistic coordination and allow for better scalability of the service. This is related to the flexibility of services to adapt to changing demand such as the accommodation of different commodities. A flexible concept adaptable to different local conditions strengthen the potential for replication. Such a concept requires a holistic and coordinated approach including vessel, loading units, handling equipment, last mile vehicles and other equipment suitable for multipurpose operation.

Standardised handling concepts that are adapted to the lack of availability of transshipment sites and the difficult infrastructural adaptation also play a certain role. Public stakeholders must also consider the development of small-scale transshipment sites. In terms of infrastructure, accessibility of locations by waterways and transhipment locations are essential. The Cityport project can serve here as an example for the provision of transshipment points, which have been set up specifically for urban waterborne operations and can be used for all services and help to reduce or bundle the setup costs of these services lowering market entry barriers while ensuring multimodality at the same time. The **limited availability of urban transshipment sites** is one of the biggest challenges. Sites are usually required outside existing inland port structures as transhipment locations near to origins/destinations in the city are needed and inland ports are usually located outside the city centre.

However, inland ports can have an important function as hubs for urban operation. Inner-city handling locations and sites contribute to materialise the advantages of waterborne logistic by serving customers (shippers and receivers) as close as possible reducing last mile operation. Quaysides for transshipment are lacking in urban areas as most of them have been redeveloped and do not provide any handling capacity. Available sites are very scarce in urban areas due to the high population density. This makes it difficult to find areas close to water that are suitable for development as transshipment centres. Various factors make this even more difficult.

On the one hand, the development of housing areas close to waterfronts is very popular, which leads to additional conflicts over the usage for areas that could be developed as transhipment sites as it was the case for the Cityport in Utrecht. Monument protection also makes the necessary infrastructure development more difficult, as many quays in city centres such as Paris and Utrecht are historic and are under special building protection due to cultural interests. These protective measures make it difficult to construct cranes or storage facilities and even toilets for workers that may be required. Hence, the state of infrastructure in the cities is a barrier for the development of services.

Alternative concepts must be applied here, such as the use of mobile cranes or the use of on-board cranes, as in Utrecht. **On-board cranes** can enable flexible and independent cargo handling in urban areas and are therefore one success factor, as several cases have shown. **Last mile operation** is an important aspect of the logistic concept as it is usually required to reach urban locations. The last mile operation does also concern the environmental sustainability of the service. Adaptation to local conditions and coordination with waterborne transport need to be considered carefully. Due to

restrictions for urban transport such as environmental zones, the use of zero emission vehicles may be required. For last mile operation, innovative vehicles such as cargo bikes and concepts relying on specific equipment can make the difference. **Micro hubs** are an additional solution to the lack of transshipment sites. This concept is relevant in various cases and has contributed to the establishment of IWT services. Micro hubs offer small-scale transshipment sites that often serve as a link to cargo bikes or other small vehicles that are used particularly in city centres. They require smaller sites, which can be developed more easily in urban areas.

An additional efficiency bonus can be achieved for IWT services by utilising the transport capacity on return journeys. For flexible services which are capable to transport different commodities it is more likely to improve the utilisation by using both legs of a roundtrip. With the Citybarge or ULS service, for example, it is often the case that different products are transported on the outward journey and packaging waste is taken on the return journey. The **utilisation of return journeys** reduces the transport cost per unit.

Besides the already mentioned lack of transhipment sites **difficult navigation conditions** are challenging as well. Navigation conditions are significantly more difficult in urban areas with narrow and shallow waterways as well as limited lock dimensions. Lock operating hours are relevant for operational and logistics planning. Additionally, urban IWT faces an increased number of obstacles such as low bridges. This limits shipping to small cargo capacities in some cases, which increases the cost per unit. Here, customised ship concepts adapted to local conditions must attempt to reduce operating costs by tailoring supply and cargo limitation. The barge should be as small as necessary to navigate on served waterways, but still allow for economies of scale. For narrow and shallow urban waterways small barges with limited dimensions providing as much as possible payload are required. Despite a lack of barge cargo capacity, the transport service cargo capacity can be increased by increasing the number of rotations and thus achieving better utilisation.

In addition to generally applicable success factors and challenges in urban and short-range waterborne freight transport, there are also conditions that only play a role in individual market segments.

The common success factors for the IWT services regarding construction materials, were the specification or **stipulation of waterborne transport in the tendering process** and the definition of incentives for the use of alternative modes of transport, such as inland waterway transport. There were various reasons for this. One important motivation was to reduce noise pollution for local residents. The stipulation in the tendering procedure promotes IWT and improves the difficult competitive situation that this mode of transport has over short distances. Here, public clients must consider the potential of IWT applications for the delivery of construction materials as part of large-scale infrastructure projects to achieve positive effects for the environment or local residents. Based on the experience gained in the good practice cases for building logistics there might be potential for an extension to other market segments.

One common success factor of cases regarding the waterborne transport of waste is the use of **ship-to-ship transshipment.** In Budapest and Rotterdam, services enable the transport of waste from hotel and cruise ships and other passenger vessels via ship-to-ship transshipment, which increases efficiency and reduces fixed costs by reducing the need for infrastructural adaptations to develop transshipment points. It also avoids unnecessary occupation of mooring points, which are often occupied in tourist centres by passenger ships.

The **e-commerce sector** is a particular growth market. The shift to digital shopping is also leading to an increase of parcel deliveries. According to a McKinsey study, every German receives an average

of 40 parcels per year, with a growth rate of 20 % per year.[20] This means that the volume of parcel deliveries will double in just a few years, which will be accompanied by a doubling of delivery traffic in cities. The share of e-commerce varies within the different member states,[21] but there is a trend here that poses new logistical challenges. This also favours the integration of IWT services into the parcel distribution networks.

For the distribution of parcels service providers have developed a complex logistics supply chain that has been maximised for the greatest possible efficiency. Converting these systems and integrating new processes or concepts into this distribution network will result in conversion costs. This worsens the competitive situation. Nevertheless, parcel delivery service providers are increasingly anticipating the importance of sustainable, environmentally friendly logistics concepts and are involved in testing various logistics concepts to find working solutions to substitute road transport. Delivery times are of particular importance in the parcel delivery service sector in order to guarantee customer satisfaction. Customers are now used to fast delivery of online orders within 24-72 hours[22], which emphasises the competition in the parcel delivery sector. This is an enormous challenge for waterborne delivery, as inland waterway vessels are not the fastest mode of transport. Moreover, the last mile using vehicles such as cargo bikes requires additional time. However, the installation of riverside parcel stations supplied by boat as implemented by DHL in Berlin could be a promising solution. A lack of transhipment concepts makes the waterborne parcel service less flexible. At the same time, the development of new transshipment points is challenging and increases fixed costs. This problem correlates with other market segments.

4.2 Success Factors and Challenges in urban passenger transport

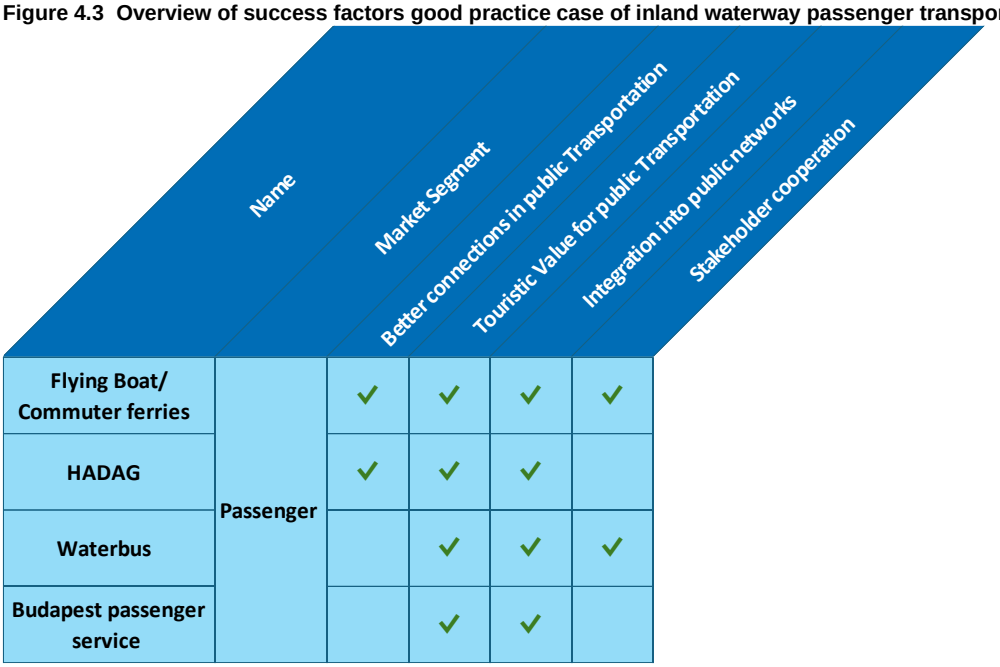
There are several challenges for passenger ferry services in urban areas. One of the biggest obstacles is the high cost of operating passenger ships and its **feasibility**. Compared to other modes of public transport, passenger ships are often more expensive to operate. It is not usual for local public transport revenues to cover the costs of the transport service, so that the operation of a local public transport network usually always has to be subsidised. Therefore, urban waterborne passenger transport is usually organised within a framework of a public service obligation.

[20] https://www.mckinsey.com/de/news/presse/2022-11-24-pakete, last access 22nd January 2024

[21] E-commerce and delivery – A study of the state of play of EU parcel markets with particular emphasis on e-commerce July 2013 European Commission – DG Internal Market and Services

[22] Parcel Market Report – Market data and competitive conditions in the postal sector as at January 2023 Bundesnetzagentur

Figure 4.3 Overview of success factors good practice case of inland waterway passenger transport



Good practice cases show that the passenger ship is one of the most expensive modes of transport in terms of the cost per passenger kilometre and the achievable cost recovery. Therefore, the need for urban waterborne passenger transport as part of the public transport network must be justified. **The urban ferry transport service** must have an **additional value** in terms of the quality of the transport connection, so that the **operation** and subsidisation of the **service receive public approval.** For instance, this is the case if the waterborne mode of transport can offer transport connections that cannot be offered on other modes of transport at all or at a poorer quality, e.g. if buses or trains have to cover longer distances due to a lack of bridges or tunnels in river areas.

The design of urban waterborne transport services should be **adapted to local conditions**. The density of **stations equipped with passenger boarding bridges or pontoons contributes to the value of the service**. The appropriate density is related to the land use and additional value in terms of connectivity determining demand for passenger transport. There is a **trade-off between the number of stops** determining the **population in the catchment area** and the **commuting speed strongly influencing the competitive position with respect to alternative modes**.

Another key success factor is the integration of **passenger ferries into the existing public transport network**. **The link of river transport with other modes** of transport such as buses, subways and trams **make it easier for commuters to use passenger ships** as part of their daily journeys to work. However, this requires close **cooperation** between stakeholders and the various transport operators and clear communication with passengers. The integration of ferry services into the local transport fare system is also important here, so that the same tickets are valid and combination of modes of transport is easily possible. But this also as well impacts cost recovery. The **leisure value** is a special aspect of waterborne passenger transport that other modes of transport cannot offer or can only offer to a limited extent. **Tourists or passengers on leisure trips are likely to use passenger ships.** This can **lead to additional demand and utilisation of the urban waterborne passenger services** but may lead to **challenges with respect to seasonal fluctuation** of demand. Those aspects should be considered in route planning and a connection to recreational points is recommended.

5 Conclusion

As part of the Study on Enabling Sustainable Management and Development of inland ports, 20 good practice cases on the integration of inland waterway transport into urban and short-distance logistics were analysed. The selection of the 20 good practice cases was based on the compilation of a list of all available cases in this market, sorted by market segment and region, to include a broadly diversified selection of IWT services in the freight and passenger sector that fulfil the conditions of the analysis. A methodological framework for the analysis was also defined, which provided an evaluation of important aspects for successful and efficient waterborne transport services. These aspects include administrative requirements, transport demand, infrastructure, vessels, logistics, competitive position and the business model. These evaluation criteria were applied in the 20 good practice examples. This provided insights into success factors, challenges and the replicability of such projects.

A key finding is the need to collaborate with relevant stakeholders to overcome challenges such as the development of transhipment centres or the creation of regulatory frameworks. This promotes sustainable transport concepts that can have a positive impact on urban development. The analysis shows that environmental zones are a key success factor that restricts the access of trucks to inner-city areas and improves the competitiveness of inland waterway transport. The use of zero emission technologies further strengthens this advantage. The acquisition of major customers is another important factor that increases the capacity utilisation and efficiency of the transport service. One challenge is the limited availability of transhipment sites, particularly in densely populated areas. Monument protection and the development of residential areas along waterways make the development of transshipment centres more difficult. Alternative concepts such as mobile cranes or micro-hubs can help here. In the area of passenger transport, high operating costs for passenger ships are a key challenge. The seamless integration of ferry services into the existing public transport network and the creation of added value for passengers are key success factors.

If the success factors and challenges are anticipated, the 20 good practice cases can serve as base for replication of their logistics concepts. The upcoming subtask 2.3 will provide a quantitative estimate of the potential for this replicability based on the knowledge gained here.