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AUTOFLEX

[D2.1] Design Basis

Design parameters, boundary conditions, model for logistics analysis defined

Work Package	WP 2	From modal shift barriers to design parameter quantification
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EXECUTIVE SUMMARY

As for every (transport) service, both the supply and the demand side need to be taken into consideration in the design phase of that service. Referring to the analysis of the supply side – equalling the task T2.1 of the AUTOFLEX project, this report – prepared by DST, DFDS, and SINTEF Ocean – presents the results of a collection of geographic, nautical, technical, and economic information about the use case areas of the envisioned AUTOFLEX transport service. Eventually, the relevant points of interest with respect to inland waterway transport in the considered geographic areas were to compile for a consolidation of requirements and framework conditions which need to be considered in the further process of designing both a novel intermodal waterborne transport system and small, flexible, automated, zero-emission inland vessels – despite the difficulties in finding consistent, coherent, comprehensive and correct data to work with.

The inland waterways with detailed information about the fairway parameters to enable efficient sailing, the berths and transshipment points for vessel and cargo handling, and the locks and weirs as well as bridges and overhead structures with their precise technical and organisational requirements to be considered form the major geographic and nautical PoIs in the two use case areas in Belgium and the Netherlands which are to be used in the further course of the research project. Particularly, the large number of maps and diagrams illustrate the matter and make the respective matter comprehensible for a wide public audience.

Several facts and findings about the two use case areas have confirmed the correctness of the selection of both and motivated the further development of the envisioned AUTOFLEX transport service, the SFAZ inland vessels, and the individual AUTOFLEX system components. The main one are listed hereafter:

- Both countries are endowed with a dense inland waterway network, featuring a considerable share of small inland waterways (of the CEMT classes I to IV).
- The two considered geographic areas of Use Case 1 and Use Case 2 comprise a total of more than 2,250 terminals of different types, offering plenty of potential for the deployment of the AUTOFLEX transport system components, such as S&C hubs, TPT, and MDC.
- Numerous larger seaports are situated in both countries.
- Both the Dutch and the Flemish inland waterway network are well-connected – with each other as well as with neighbouring networks, such as the Wallonian waterways, the French waterways, the West German Canal network and – last but not least – the Rhine and the Rhine-Alpine Corridor as Europe's busiest inland waterway corridor.
- Both countries feature sufficient economic activity and, thereby, potential for domestic and regional waterborne transports – either as part of seaport hinterland traffic or of continental transports.
- Both Belgium and the Netherlands exhibit a large number of operators (and other members of the respective IWT ecosystems) which already operate on the larger waterways of both countries, and which could easily expand their operation to the smaller waterways with SFAZ inland vessels once proven technically feasible and economically viable.

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LIST OF ABBREVIATIONS

Abbreviation	Description
AIS	Automatic Identification System
CCNR	Central Commission for the Navigation of the Rhine
CEF	Connecting Europe Facility
CEMT	Conférence Européenne des Ministres des Transports[1]
DC	Distribution Centre
ERI	Electronic Reporting International
GDP	Gross Domestic Product
GDWS	Generaldirektion Wasserstraßen und Schifffahrt[2]
IENC	Inland Electronic Navigational Charts
ISRS	International Ship Reporting Standard
IWT	Inland Waterway Transport
KPI	Key Performance Indicator
MDC	Mobile Distribution Centre
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne[3]
NST	Nomenclature uniforme des marchandises pour les statistiques de transport[4]
NtS	Notices to Skippers
NUTS	Nomenclature d'unités territoriales statistiques[5]
PoI	Point of Interest
RIS	River Information Services
S&C	Stow & Charge Hub
SFAZ	Small, flexible, automated, zero-emission [inland vessels]
SIMPACT	SIMulation based ship concept imPACT evaluation tool
TPT	Temporary Port Terminal
UNECE	United Nations Economic Commission for Europe

1 French: European Conference of Ministers of Transport (*The European Conference of Ministers of Transport established a classification of waterways in 1953 which was later expanded to take into account the development of push-towing.)*
2 German: Directorate-General for Waterways and Shipping (*German Waterway Authority*)
3 French; Statistical Classification of Economic Activities in the European Community
4 French; Standard goods classification for transport statistics
5 French; Nomenclature of territorial units for statistics

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1 INTRODUCTION

1.1 THEMATIC AND CONTENT CLASSIFICATION

1.1.1 THE AUTOFLEX PROJECT

The project "**AUTOnomous small and FLEXible vessels**" (AUTOFLEX) enables zero-emission (waterborne and road) transport by means of small, automated, climate-neutral and -resilient inland vessels and innovative port infrastructure. The new intermodal transport service is based on safe and efficient fully automated and connected inland shipping and requires integration into logistic chains. The ultimate objective of the AUTOFLEX project lies in the reduction of societal and climate impacts of transportation which it pursues by developing viable solutions facilitating a modal shift from road to inland waterway transport and the electrification of both modes.

For the deployment of an attractive intermodal transport service, the integration of the different service components with one another and with connected external services via its interfaces is of utmost significance. In the case of electrification of the transport modes, the effects on both vessel operation and truck operation need to be taken into consideration – with respect to battery range and recharging operations, for instance. Particularly, the coordination of cargo-related and energy-related planning and operation gains importance.

Therefore, the scope of the AUTOFLEX project encompasses:

1) developing small autonomous uncrewed zero-emission inland vessels that can operate on underutilised waterways (of lower CEMT classes), that are resilient towards extreme low-water events, and are competitive;

2) developing transport system components and a system architecture of an intermodal transport service that enables smooth transhipment between transport modes, and, thereby, strong competition with (unimodal) road transport as well as new market segments, such as urban distribution and new cargo segments;

3) developing a combined cargo and energy hub (Stow & Charge) for generating and distributing electric energy for the transport system;

4) developing new business models for offering an intermodal transport service and operating the underlying transport system and its system components, and exploiting new market segments using the new transport system (e. g., energy distribution and urban logistics);

5) validating the inland vessel concepts and the configurations of intermodal transport system through simulation and quantitative analyses, scale model testing and demonstration, and full-scale demonstration; and

6) developing a roadmap for exploitation, recommendations to policy and industry, steps towards realisation, and proposing interface standards to Key Enabling Technologies.

The AUTOFLEX project addresses the call "Developing small, flexible, zero-emission and automated vessels to support cargo from road to sustainable waterborne transport"

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1.1.2 WORK PACKAGE 2: FROM MODAL SHIFT BARRIERS TO DESIGN PARAMETER QUANTIFICATION

The second work package (WP 2) of the AUTOFLEX project, named "**From modal shift barriers to design parameter quantification**" refers to the underlying design parameters of both the intermodal transport system and the small, automated, flexible, and zero-emission inland vessels. For that purpose, the boundary conditions in the economic and geographic setting of the two use cases need to be identified, determined, and quantified with respect to their role as parameters for the design processes of the inland vessels and the intermodal transport system. Moreover, the requirements and performance targets of the intermodal transport system are to be defined in order to overcome modal shift barriers and appear as an attractive alternative to road transport. Moreover, the work package includes a profound analysis of the transport market in two use case areas so that both the supply and demand sides of the intermodal transport service are analysed.

With the help of interviews with selected stakeholders, the decision-making process behind the mode choice in favour of or against a particular transport mode, particularly inland waterway transport, is to be analysed and comprehended in order to address the adoption barriers during the design process of the transport system.

In addition, suitable and meaningful key performance indicators are to be identified in order to be capable of evaluating the intermodal transport system developed in the AUTOFLEX project. For a thorough evaluation, the new AUTOFLEX transport system needs to be modelled using as many real-world logistic data as possible and examined with an effective examination and evaluation method like logistics simulation. The existing evaluation tools of the partners are to be developed further considering the particularities of the envisioned intermodal transport service and the two use cases.

Eventually, the work in WP 2 yields a foundation for novel business models by identifying and examining existing transport systems and services and modelling a business case for the new AUTOFLEX transport system, ideally closing a gap of missing logistical offerings in the two use case areas considered.

1.1.3 TASK T2.1: QUANTIFY DESIGN PARAMETERS AND BOUNDARY CONDITIONS

As for every (transport) service, both the supply and the demand side need to be taken into consideration in the design phase of that service. The task T2.1 entitled "**Quantify design parameters and boundary conditions**" focuses on the supply side as it is to compile information about the elements potentially to be integrated into the new AUTOFLEX transport system.

The elements, so-called points of interest, refer to the physical, digital, and organizational setting of the transport system to be designed and mainly include geographic data (albeit not exclusively). These points of interest act as design parameters in the pertaining processes of transport system design and inland vessel design. As a result, the underlying design parameters of both the **intermodal** transport system and the small, automated, flexible, and zero-emission inland vessels are to be derived from the economic and geographic boundaries of the envisioned new intermodal transport system. Earlier works have already described the process of collecting the relevant information for the same purpose which are therefore used as a base for the work in this task (Alias, Dahlke, et al., 2020).

Precisely, the inland waterways of the two use cases are used as the base of the design processes of both the intermodal transport system and the small, automated, flexible, and zero-emission inland vessels. On analysing the principally possible points of interest, the service area of the envisioned new intermodal transport service is defined. The set of potential points of interest mainly consist of inland waterways in the geographic area. With the help of geographic and nautical information of the fairways, which can be retrieved from national and supranational waterway authorities and other stakeholder organisations, candidate waterways for the AUTOFLEX transport system can be identified and collected. Similarly, the potential berths, locks, transshipment points, and a series of other points are collected, examined, and evaluated. The totality of the points of interest will serve as the initial set of design parameters of both the vessel design process and the transport service development process. In alignment with the work in task T2.2 ("Transport demand modelling (market analysis)"), the set is to be refined to the actually relevant transport relations and service area covered by the new AUTOFLEX transport system.

Apart from the geographic information, further process-related information, such as the traffic density of the selected waterways or the process times and costs of both unimodal road and inland waterway transport and intermodal transport (using both modes), are to be examined. In addition, the statistical fluctuations of the values are to be determined by means of official statistics, reports of empirical research, or expert interviews with market players. Likewise, the likelihood and the stochasticity of the occurrence of relevant disturbances like canal obstructions and extreme low-water events need to be identified and incorporated in the design process.

Task T2.1 is to be conducted by the AUTOFLEX consortium members Fraunhofer Center for Maritime Logistics and Services, ISE Institut für Strukturleichtbau und Energieeffizienz gGmbH, DFDS AS, and DST – Development Centre for Ship Technology and Transport Systems (task lead) from project month M02 to M12.

Furthermore, the document includes initial findings of the tasks T2.3 ("Existing transport systems and services") and T2.4 ("Simulation model for logistical analysis") which complement the findings of task T2.1. While T2.3 provides for a gap analysis on potentially missing logistical offerings based on a mapping of the existing transport solutions available today, T2.4 pursues the functional expansion of the SIMPACT tool intended to be used for logistical simulations and analyses of the AUTOFLEX transport system (Tangstad, Nordahl, Kisialiou, et al., 2023). Thus, the results of T2.1 will be directly used in the work on T2.4 as the operation of various points of interest, such as relevant locks and bridges, needs to be represented in the SIMPACT environment. While the results of T2.3 will directly also feed the design activities around the AUTOFLEX transport system (in WP 3) and the business model development (in WP 5), the outcome of T2.4 will enable the work on the architectural re-design and the performance validation (in WP 3) as well as fertilise the work on the design and development small automated zero-emission inland vessels (in WP 4).

1.2 DATA COLLECTION

The main data for the geographic analysis has been retrieved from the publications and databases of the national waterway authorities, such as Rijkswaterstaat, De Vlaamse

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Waterweg, and Generaldirektion Wasserstraßen und Schifffahrt (GDWS). Particularly, the geographic information provided about inland waterways and their various waypoints and the nautical information for skippers and vessel crew members proved to be of utmost value during the data collection, verification, and analysis processes.

Another important source of information was the online platform EuRIS[6], which was published for the first time in September 2022 by 13 European waterway administrations following the successful completion of the CEF-funded multi-beneficiary project RIS COMEX[7] running from 2016 to 2021 and regularly updated afterwards. EuRIS allows for traffic management by the authorities and transport management by the logistics sector as it covers the largest interconnected inland waterway network in Europe and provides access to static and dynamic information and thus a 24/7 insight into the waterways to heterogeneous users, such as skipper, vessel owner or logistic operator on the main European waterways as well as administration and academia. Basically, it consists of the datasets of the national River Information Service (RIS) portals. RIS is a set of harmonized information services that support traffic and transport processes in inland navigation. Using these tools, traffic safety improves and transport efficiency is enhanced. RIS focuses on the exchange of traffic and transport related information between all Inland Waterway Transport (IWT) stakeholders. According to official information, numerous services relevant to RIS, such as Notices to Skippers (NtS), Electronic Reporting International (ERI), Inland Electronic Navigational Charts (IENC) and the Automatic Identification System (AIS) for vessel tracking and tracing, are already in operation and can be accessed and used by any (registered) user via the EuRIS portal,. (EuRIS; *What Is EuRIS?*, 2022)

Figure 1-1 shows the data retrieved from the EuRIS portal and combined for further analysis documented in this report. The last retrieval dates of the data and information related to Use Case 1 are from mid-November 2024 whereas the data and information about Use Case 2 stems from mid-December 2024. Based on the RIS Index, which is a standardized format for the georeferenced description of waterway infrastructure, various points of interest in the inland waterway transport domain are elaborated upon by additional information. Each point of interest has a unique ISRS Location Code, which is a unique identifier for each unique part of the infrastructure of importance for RIS. Amongst others, the ISRS code consists of the so-called UN/LOCODE, a geographic code by UNECE for trade and transport locations (Rijkswaterstaat, 2020).

Apart from the EuRIS portal and the databases of the national waterway authorities, additional sources like vessel operation manuals issued in the different European countries and reports of former national and international projects and international organisations and committees have been used.

Despite the broad information base, it must be emphasised at this point that the underlying sources sometimes contain errors and incorrect or missing values, some of which are still being eliminated step by step. In some cases, such errors have been detected and identified as such, communicated to the bodies responsible for the maintenance and management of the database, and corrected manually in the context of the AUTOFLEX project.

[6] EuRIS portal, www.eurisportal.eu
[7] RIS Corridor Management Execution, www.riscomex.eu

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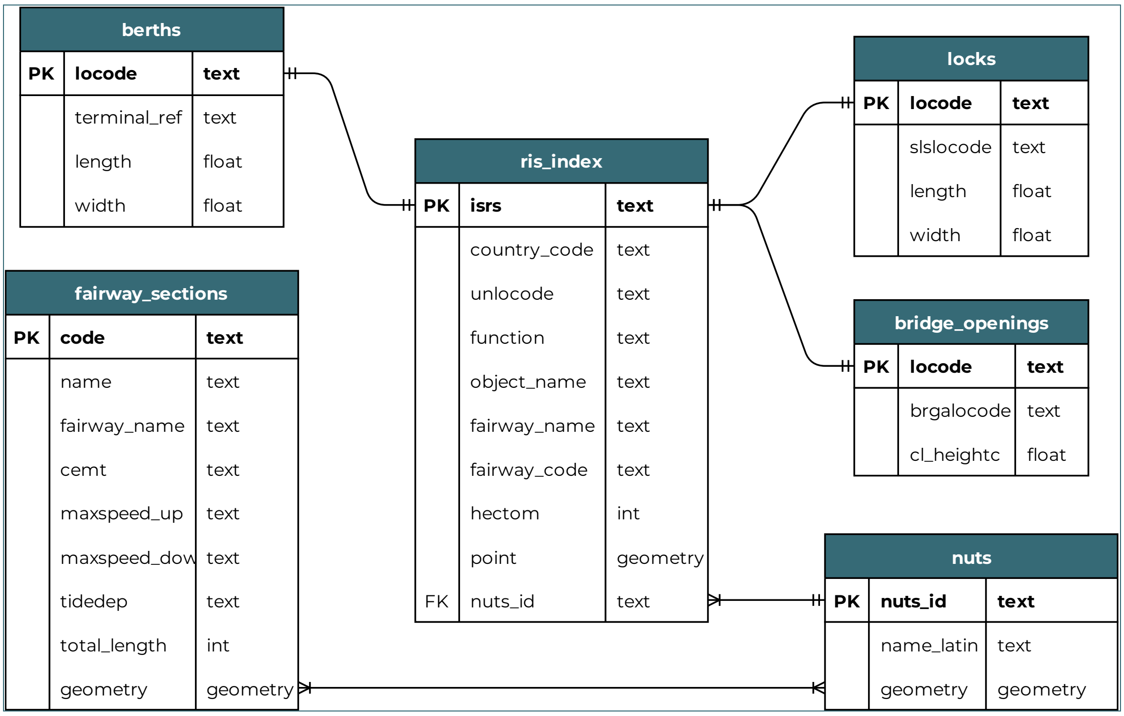

Figure 1-1: Datasets based on data retrieved from publicly accessible EuRIS portal

These errors may include

- the missing CEMT classification of waterways (leading to the assignment of a waterway to class CEMT 0 and uncategorized waterways as shown in Figure 1-2),
- erroneous assignment of bridges and locks to certain waterways (e. g., when located at the junction of two waterways),
- unclear and contradictory information about maximum permitted speed on many waterway stretches,
- missing (or obsolete) information about berthing or transshipment facilities at potential terminals and transshipment points, and
- obsolete information about the operation of locks and bridges (e. g., with respect to operating times or dimensions prior or after renovation) –

and may lead to consequential errors, such as wrong information on the optimal route between origin and destination, the transit time of a particular transport relation, or the accessibility of a particular route or particular transshipment points with certain vessel and cargo types.

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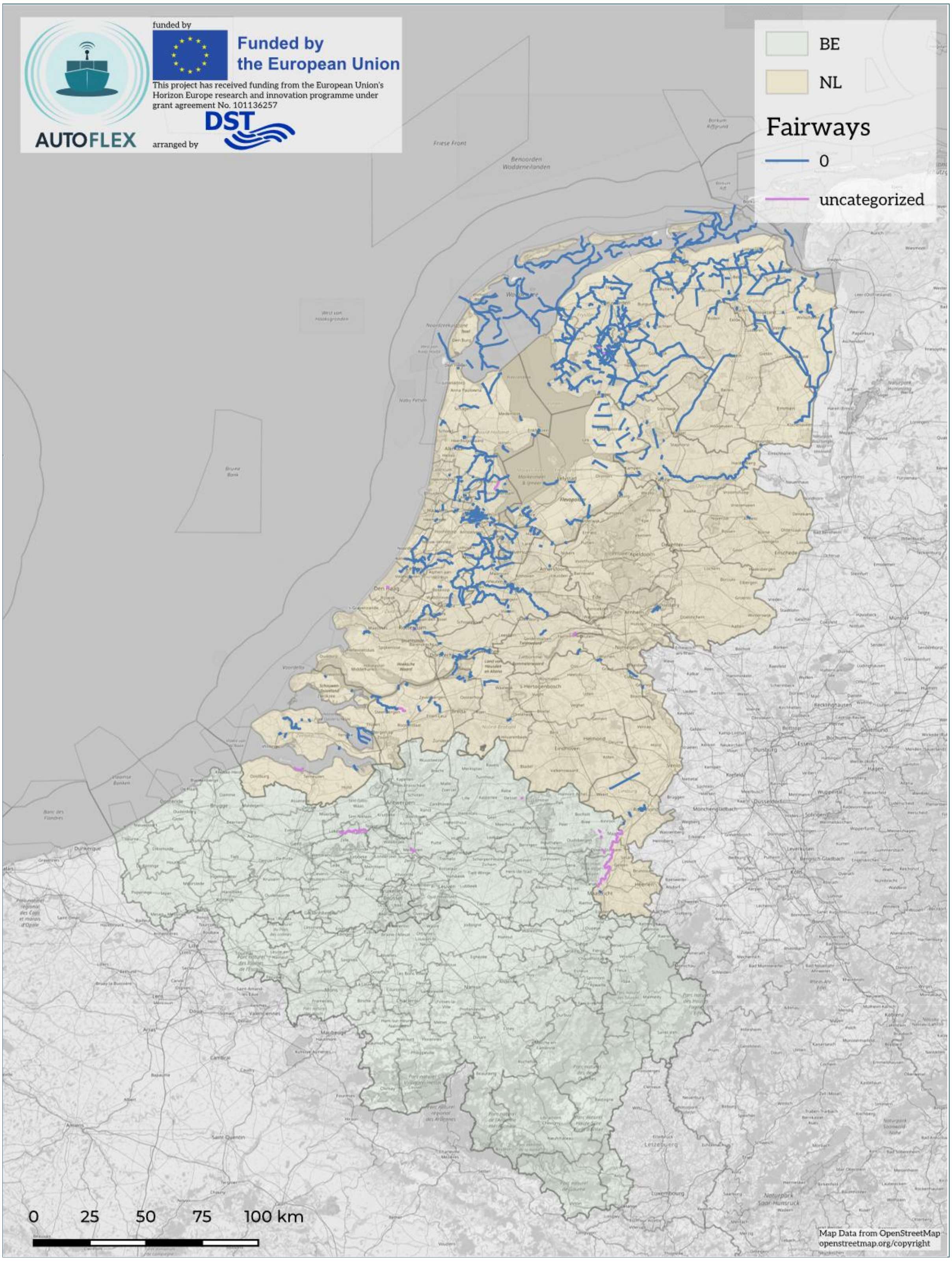

Figure 1-2: Inland waterways of the CEMT class 0 in Belgium and the Netherlands

In the case of the missing classification of inland waterways, the clarification of the concrete significance of CEMT class 0 in Belgium and the Netherlands showed some weaknesses as their definition is not homogeneous or even standardised throughout Europe: the inland waterways beyond the typical CEMT classes I to VII need to be differentiated between those of CEMT class 0 and the uncategorized waterways. While the latter refer to waterways not suitable for commercial shipping or general waterborne traffic, CEMT class 0 generally represents those waterways that may not be classified as official waterways but allow some other form of general traffic. This is the interpretation in several European countries.

In the case of the Netherlands (and France), however, CEMT class 0 is used for particularly small fairways which are navigable for small vessels with a loading capacity below 250 tonnes, a vessel beam of maximum 5.00 metres, and a vessel length of not more than 38.00 metres. Since the measures are slightly lower than the official (Europe-wide) CEMT class thresholds and the AUTOFLEX project refers to CEMT class I inland vessels (with a vessel length of between 38.50 metres and less than 55.00 metres) as smallest elements in the fleet, the CEMT class 0 categorisation of the Netherlands is not included in the following considerations. Fairways which are only navigable by very small vessels (e. g., canoes) are also excluded from the EuRIS fairway network. Figure 1-2 shows a few uncategorised waterway stretches in Flanders and even fewer in the Netherlands whereas waterways of class 0 are abundantly existent in the Netherlands and an unknown phenomenon in Belgium.

Since the EuRIS portal is a public information portal which is managed and maintained regularly, constant updates from the national waterway authorities are immediately fed into the underlying databases. Hence, it can happen that the data used for an analysis over a few weeks or months may turn out to be outdated as the underlying database may have been updated and new information included. During the work on task T2.1 of the AUTOFLEX project, this has happened several times, leading to the need for new approaches of processing and analysing data, further extra work, and, thus, delays in the regular progress of the work.

Another difficulty lies in the renewal of the NUTS classification as of 1 January 2024. Some regions in Europe have undergone changes in the assignment of the municipalities to the NUTS regions. In total, the number of NUTS regions on levels 2[8] and 3[9] has changed as well as the municipalities assigned to these. In the Netherlands, which accommodates one of the two use cases of the AUTOFLEX project, the so-called COROP[10] regions in the Netherlands are affected (see Figure 1-3). More precisely, several codes needed to be changed due to a border shift between the NUTS-2 regions Utrecht (NL350) and Zuidoost-Zuid-Holland (NL364) and six boundary shifts affecting two regions in each case. Table 1-1 shows the differences in the assignment of the Dutch regions between NUTS 2021 and NUTS 2024.

[8] NUTS level 2: basic regions (for regional policies)

[9] NUTS level 3: small regions (for specific diagnoses)

[10] *Coördinatiecommissie Regionaal Onderzoeksprogramma* (Dutch; Coordination Commission Regional Research Programme), a division of the Netherlands for statistical purposes, used by the *Centraal Bureau voor de Statistiek* (Dutch; Central Agency for Statistics of the Netherlands)

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Table 1-1: Overview of Dutch and Belgian NUTS regions undergone change between 2021 and 2024

Code 2021	Code 2024	NUTS level 2	NUTS level 3	Change
BE31	BE31	Prov. Brabant wallon		Name change
NL111			Oost-Groningen	Boundary shift
	NL114		Oost-Groningen	New region
NL113			Overig Groningen	Boundary shift
	NL115		Overig Groningen	New region
NL124			Noord-Friesland	Boundary shift
	NL127		Noord-Friesland	New region
NL125			Zuidwest-Friesland	Boundary shift
	NL128		Zuidwest-Friesland	New region
NL31		Utrecht		Boundary shift
	NL35	Utrecht		New region
NL310			Utrecht	Boundary shift
	NL350		Utrecht	New region
NL33		Zuid-Holland		Boundary shift
	NL36	Zuid-Holland		New region
NL33A			Zuidoost-Zuid-Holland	Boundary shift
	NL364		Zuidoost-Zuid-Holland	New region
NL332	NL361		Agglomeratie 's-Gravenhage	Code change
NL333	NL362		Delft en Westland	Code change
NL337	NL363		Agglomeratie Leiden en Bollenstreek	Code change
NL33B	NL365		Oost-Zuid-Holland	Code change
NL33C	NL366		Groot-Rijnmond	Code change
NL324			Agglomeratie Haarlem	Boundary shift
	NL32A		Agglomeratie Haarlem	New region
NL329			Groot-Amsterdam	Boundary shift
	NL32B		Groot-Amsterdam	New region
NL412			Midden-Noord-Brabant	Boundary shift
	NL415		Midden-Noord-Brabant	New region
NL413			Noordoost-Noord-Brabant	Boundary shift
	NL416		Noordoost-Noord-Brabant	New region

While a large portion of the statistical information on geographic and economic aspects refers to the NUTS-3 classification of 2021, the latest maps are based on the update of 1 January 2024. In order to avoid confusion and misunderstanding, the NUTS-3 classification of 2021 has been used during the work on the task T2.1 because most of the relevant information referred to the earlier classification.

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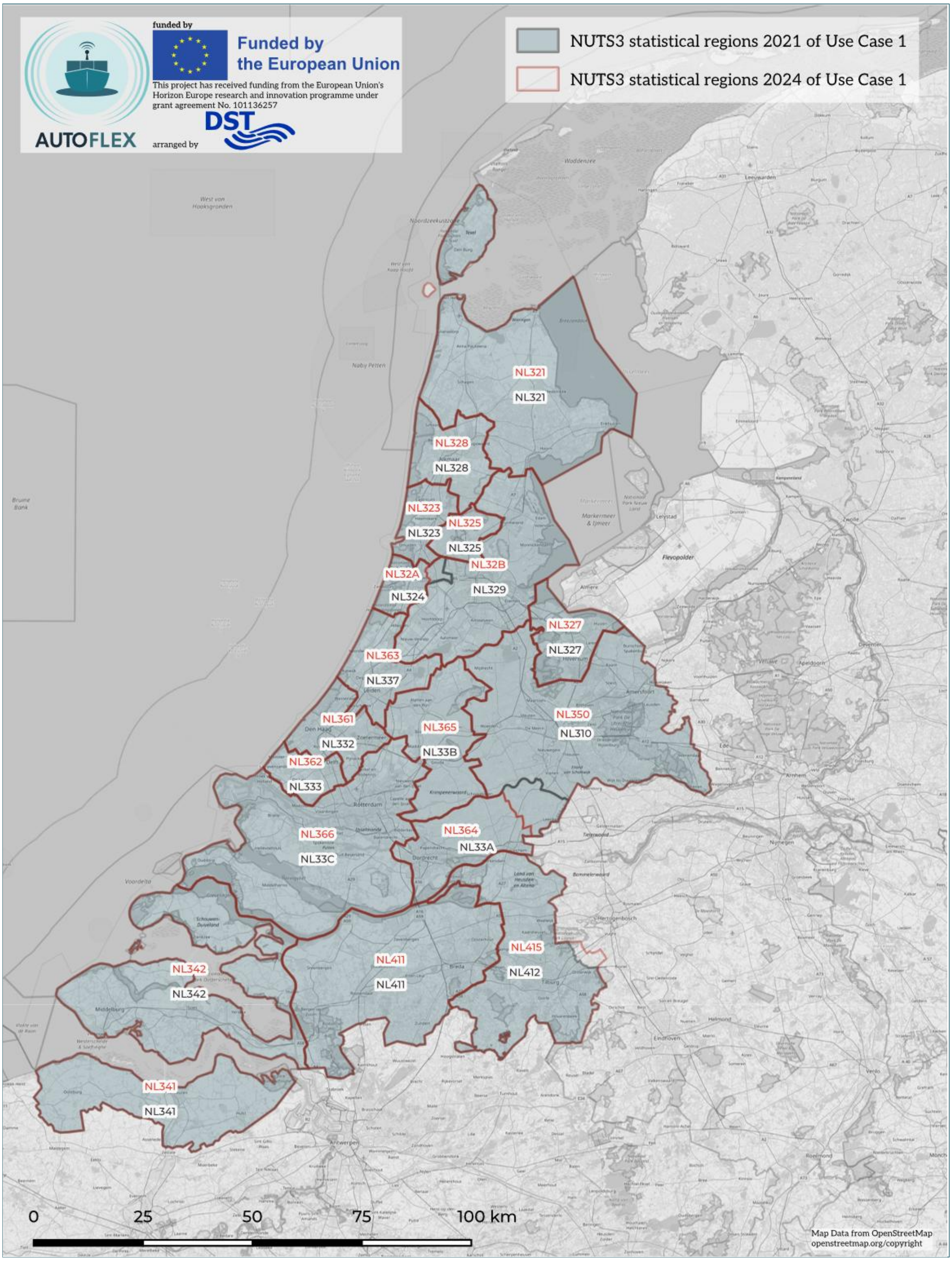

Figure 1-3: Differences in NUTS-3 classification of the service area of Use Case 1 of the AUTOFLEX project between 2021 and 2024

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2 AUTOFLEX USE CASES

Small, flexible, automated, zero-emission inland vessels (SFAZ) appear particularly appropriate and attractive for local and regional transports, which typically excludes international transports across country borders, and, thus, are likely to be introduced in regions and countries in which domestic use of inland waterway transport is already known and well-established. In the northwestern part of continental Europe, transporting freight (and passengers) on inland waterways, such as rivers, canals, and estuaries, has a long and vivid tradition and is a well-established transport mode footing on an intensively developed waterway network (Glerum, 1983; van Hassel, 2015). The Netherlands exhibit a share of 40 percent of the domestic freight transport by inland waterway transport while the Belgian region of Flanders, which neighbours the Netherlands and accommodates large seaports like Antwerp, Ghent, and Zeebrugge, achieves 11.5 percent for the same mode ("Inland Waterways Can De-Stress City Roads," 2016). Hence, the two use cases of the AUTOFLEX project are situated in Flanders and the Netherlands. Figure 2-1 shows the inland waterways in the Netherlands and Flanders. Due to the omnipresence of CEMT class 0 waterways (as well as uncategorised waterways) particularly in the Netherlands, which are not going to be addressed in the AUTOFLEX project, the reference waterway network for the project excludes those two categories (see Figure 2-2). Since the focus of the research project lies on small inland vessels. Typically, this translates into inland vessels of not more than 86 metres and, thus, inland waterways below CEMT class V. Hence, the corresponding waterways in Belgium and the Netherlands represent the focal part of the AUTOFLEX project whereas the larger waterway network is already served by commercial actors and addressed in other research projects. Figure 2-3 shows the geographic distribution of the different waterway classes across the two countries.

Both use cases of the AUTOFLEX project are to be able to show the technical feasibility and economic viability of a new intermodal transport service based on small, flexible, automated, zero-emission inland vessels which are to be used for small and medium-sized distances in a dense network of (both smaller and larger) inland waterways.

The requirements derived from the use cases will feed into the design work of both the intermodal transport system and its individual components and the inland vessel for the cargo transport task. Moreover, they will be used for validation purposes during the evaluation work in the aftermath of the design, development, and (theoretical) deployment of the inland vessel and the waterborne transport service.

Moreover, the demonstration of the innovations developed in the AUTOFLEX project, i. e., the autonomy concept and the autonomous navigation of canals and locks (using CCNR automation level 3) belongs to the project objectives. The full-scale demonstration of the autonomous navigation of canals and locks is expected to take place on the Ghent – Terneuzen Canal and in the Terneuzen lock.

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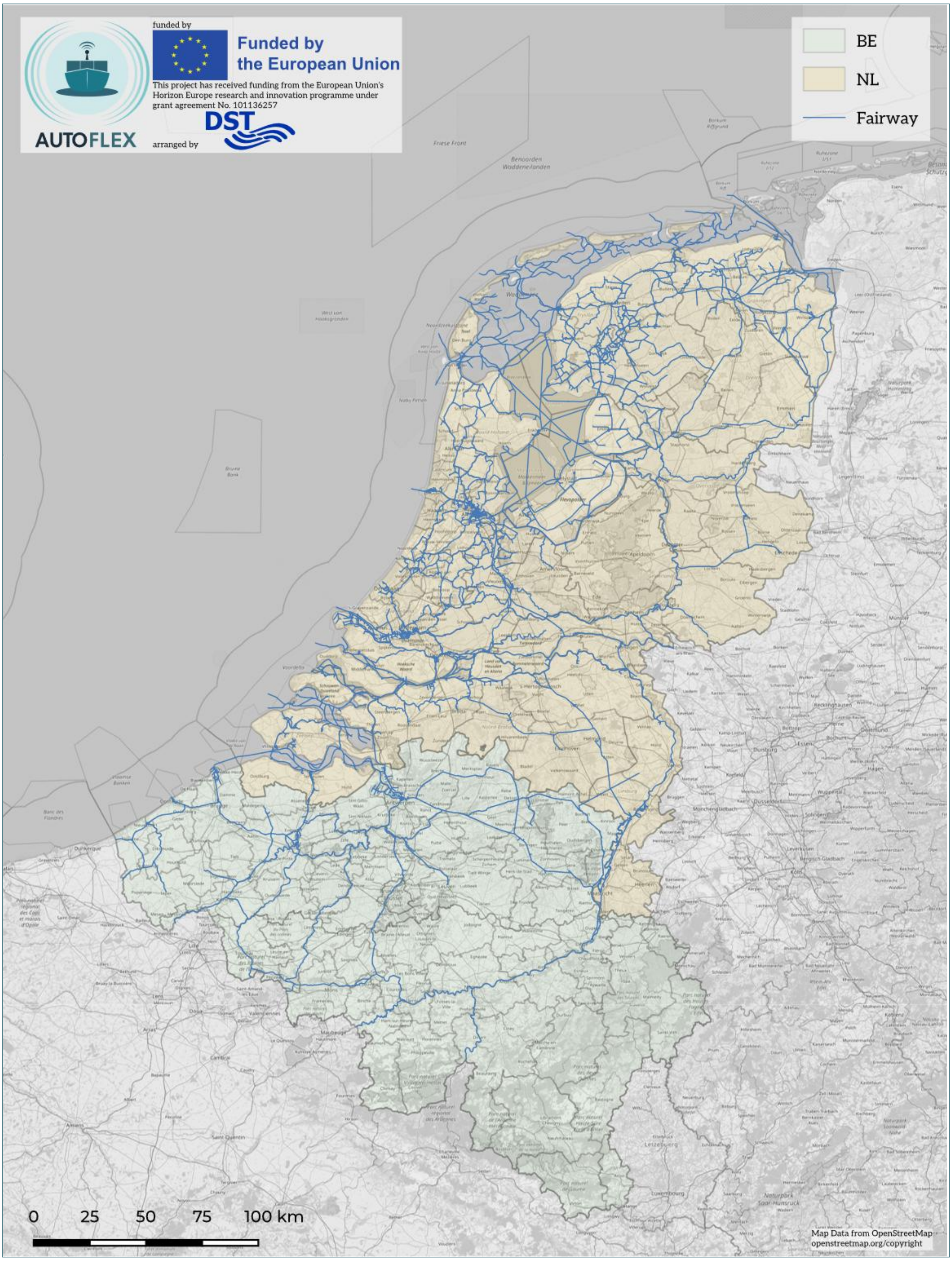

Figure 2-1. Inland waterways in Belgium and the Netherlands

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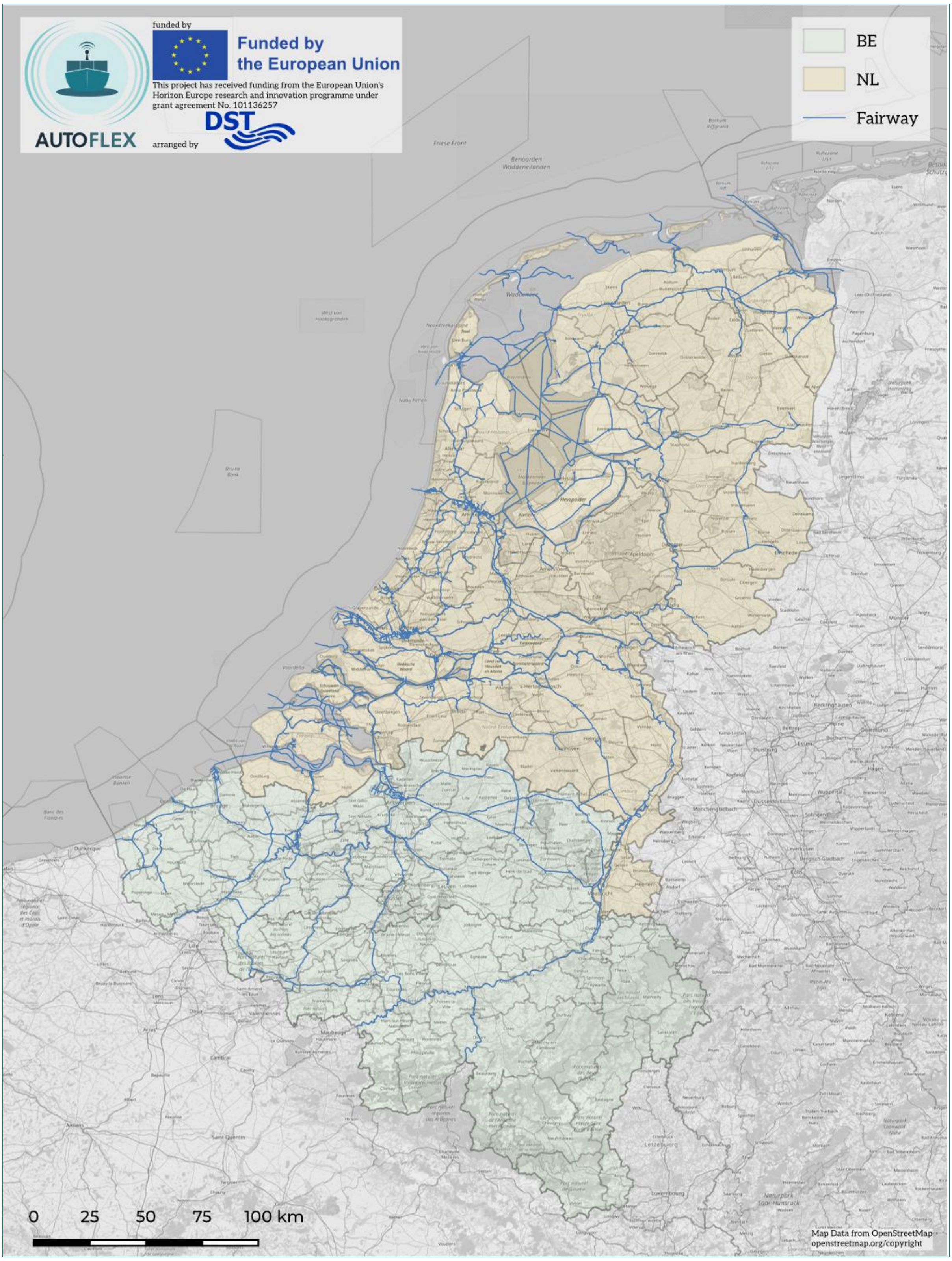

Figure 2-2: Inland waterways in Belgium and the Netherlands (excl. class 0 and uncategorised waterways)

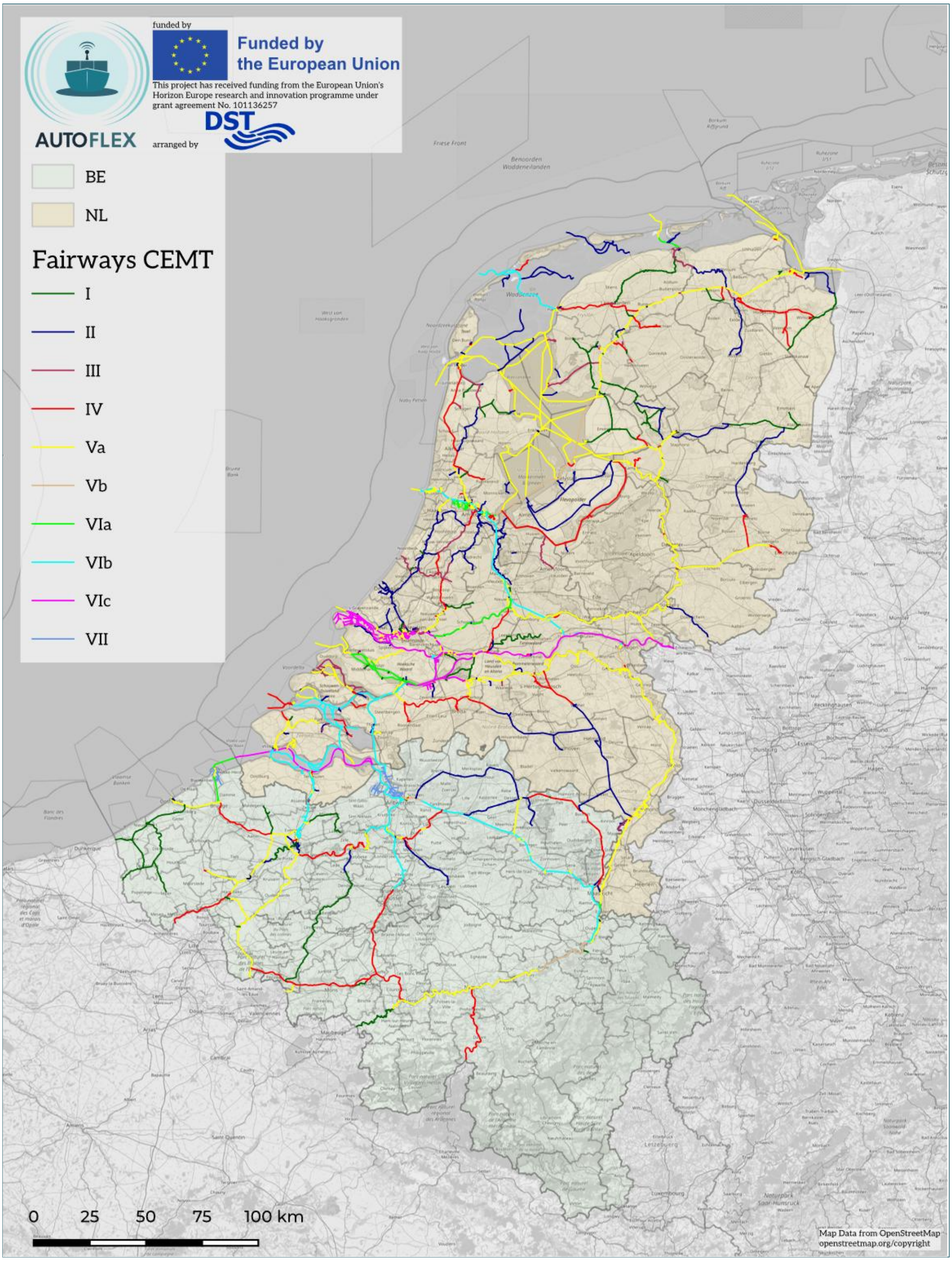

Figure 2-3: CEMT classes of inland waterways in Belgium and the Netherlands[11]

[11] excl. class 0 and uncategorised inland waterways

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2.1 USE CASE 1: THE MOST CONGESTED ROADS IN THE NETHERLANDS

2.1.1 USE CASE FOCUS

Being one of the most densely populated countries in Europe, the Netherlands features areas with extreme high population density. The Dutch conurbation of Randstad, which translates into "rim city" or loosely "ring city", includes the large metropolitan areas of Amsterdam, Rotterdam, Den Haag[12], and Utrecht and accommodates approximately 8.5 million inhabitants. In economic terms, the area is considered to belong to the five strongest metropolitan areas in Europe with a gross regional domestic product of 510 billion euro in 2022. Apart from the four above-mentioned cities with minimum 350,000 inhabitants each, twelve more cities feature 100,000 inhabitants or more (as of 2021).

The density in population and economic activity is mirrored by the traffic density as the region accommodates one of the largest European seaports, the busiest airports of Europe, and a large number of highways, railways and inland waterways connecting the different cities and agglomerations with one another. Particularly, road traffic in the area is heavy with the three busiest highways of the entire country (i. e., A13 between Rotterdam and Den Haag, A10 encircling Amsterdam, and A12 from Utrecht to Den Haag) running through the area. Similarly, the provinces of Utrecht, Zuid-Holland, and Noord-Holland, all three part of Randstad, are the ones with the highest traffic in the country. With the North Sea – Baltic TEN-T[13] Corridor passing through the Randstad region (via the highways A13 and A4) as well as the large waterways situated in the area, the elevated significance of the region with respect to connectivity is evident. The main waterway connection from Amsterdam via Utrecht and Rotterdam to Hoek van Holland forms a half ring which encloses the core of the Randstad region in its centre and, thus, is considered as the outer ring.

Apart from the large waterways, a set of smaller waterways ranging from CEMT classes I to VI form a regional network, stretching into the cities and urban areas of the Randstad region. These waterways include domestic waterway corridors between Rotterdam and Ijmuiden via Utrecht and Amsterdam (CEMT class VI), between Rotterdam and Amsterdam (CEMT classes II, III, IV, and V), between Rotterdam and Ijmuiden via Delft, Den Haag, Leiden, and Haarlem (CEMT class II), and a couple of longitudinal and transversal waterway corridors and urban connection branches of the CEMT classes I to III. Apart from the CEMT class V relation, these domestic routes hardly bear major inland waterway traffic nowadays.

As part of the AUTOFLEX project, the Use Case 1 will examine the possibility of the tailored development and establishment of an intermodal transport service mainly footing on inland waterway transport for distributing into cities and urban areas and using (electric) trucks for short, first- and last-mile transport only. The envisioned transport service is designed to facilitate modal shift from road to IWT by means of the underutilised small waterways.

2.1.2 USE CASE AREA

According to the above-mentioned focus on the Randstad region and the adjacent area with a sufficiently large waterway network, the following NUTS-3 regions have been included in the consideration:

[12] The Hague (alternatively, s'Gravenhage)
[13] Trans-European Transport Network

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- NL31 (Utrecht) with
  - NL310 (Utrecht),
- NL32 (Noord-Holland) with
  - NL321 (Kop van Noord-Holland),
  - NL323 (IJmond),
  - NL324 (Agglomeratie Haarlem),
  - NL325 (Zaanstreek),
  - NL327 (Het Gooi en Vechtstreek),
  - NL328 (Alkmaar en omgeving), and
  - NL329 (Groot-Amsterdam),
- NL33 (Zuid-Holland) with
  - NL332 (Agglomeratie 's-Gravenhage),
  - NL333 (Delft en Westland),
  - NL337 (Agglomeratie Leiden en Bollenstreek),
  - NL33A (Zuidoost-Zuid-Holland),
  - NL33B (Oost-Zuid-Holland), and
  - NL33C (Groot-Rijnmond),
- NL34 (Zeeland) with
  - NL341 (Zeeuwsch-Vlaanderen) and
  - NL342 (Overig Zeeland), as well as
- NL41 (Noord-Brabant) with
  - NL411 (West-Noord-Brabant) and
  - NL412 (Midden-Noord-Brabant).

Figure 2-4 shows the service area of Use Case 1 in the Netherlands which includes the Randstad region in its core but also the neighbouring provinces and regions in the western part of the Netherlands.

Acc. to the EuroStat data on GDP of the year 2021, the selected Use Case 1 area encompassing the above-mentioned NUTS-3 regions are heterogeneous in value-creation with grossly different gross regional domestic products as can be seen in Figure 2-5. Particularly, the regions around the large agglomerations of Amsterdam, Rotterdam/Den Haag, and Utrecht appear as economically savvy and successful (Eurostat, 2024a, 2024b).

Similarly, the Randstad region and the Use Case 1 area belong to the most densely populated regions of the entire continent. Particularly the above-mentioned metropolitan areas feature large numbers of inhabitants per square kilometre. Apart from Amsterdam, Den Haag, Rotterdam, and Utrecht, a series of smaller cities exhibit fairly high population densities. This applies to cities like Leiden and Haarlem along the North Sea coast, smaller cities in the vicinity of the big metropolitan areas like Delft and Dordrecht, and the four major cities in the southern province of Noord-Brabant, i. e., Bergen op Zoom, Roosendaal, Breda, and Tilburg (Eurostat, 2023, 2024a). Figure 2-6 shows the population density in the Use Case 1 area acc. to EuroStat data of the year 2021.

Both the economic activity in the region and its population density justifies the selection of a use case area from this region of Europe. In combination with the existing dense waterway network in the region, the Use Case 1 area appears as a promising experimental area for the design, development, and deployment of a new intermodal transport service in the AUTOFLEX project.

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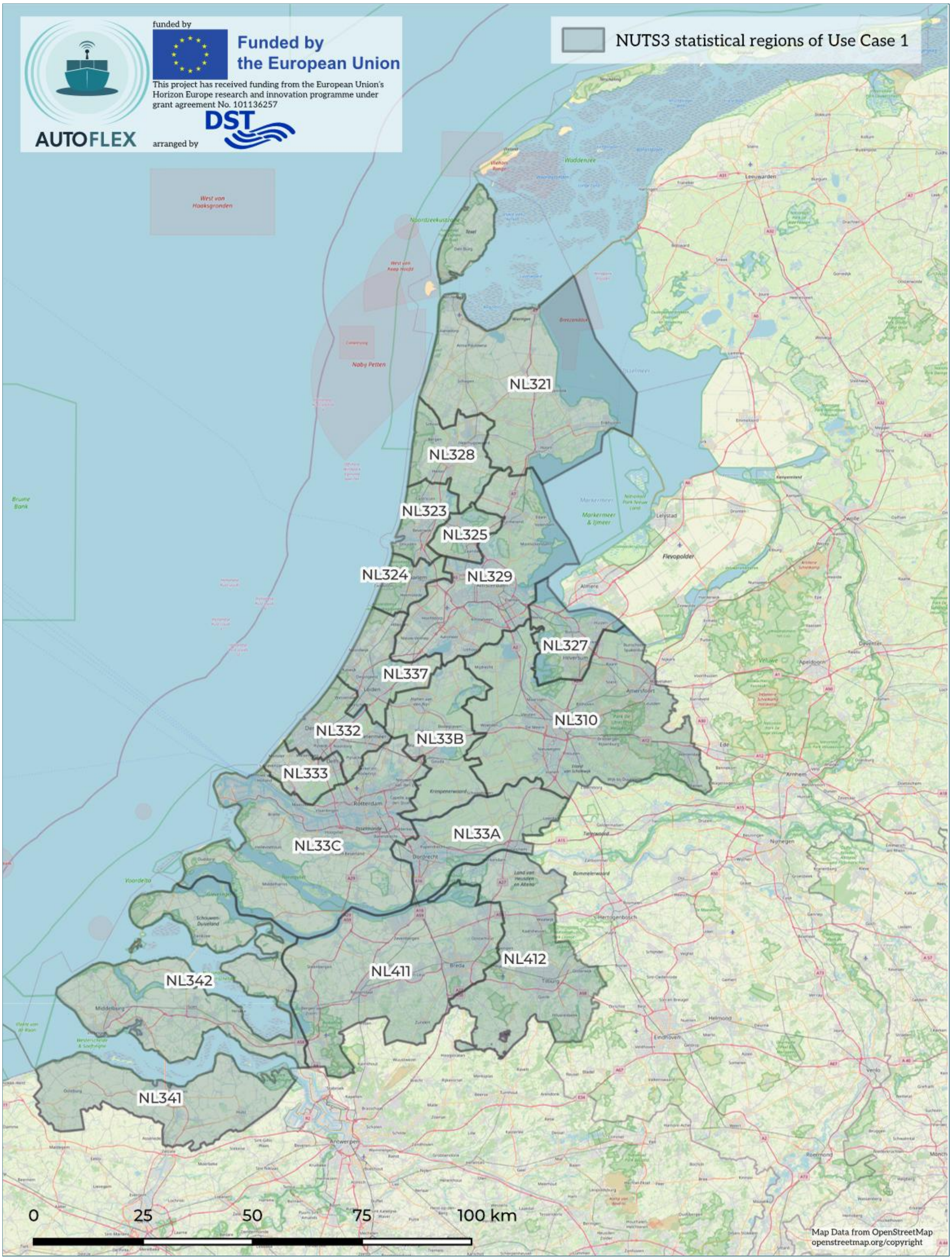

Figure 2-4: Service area of Use Case 1 (Netherlands)

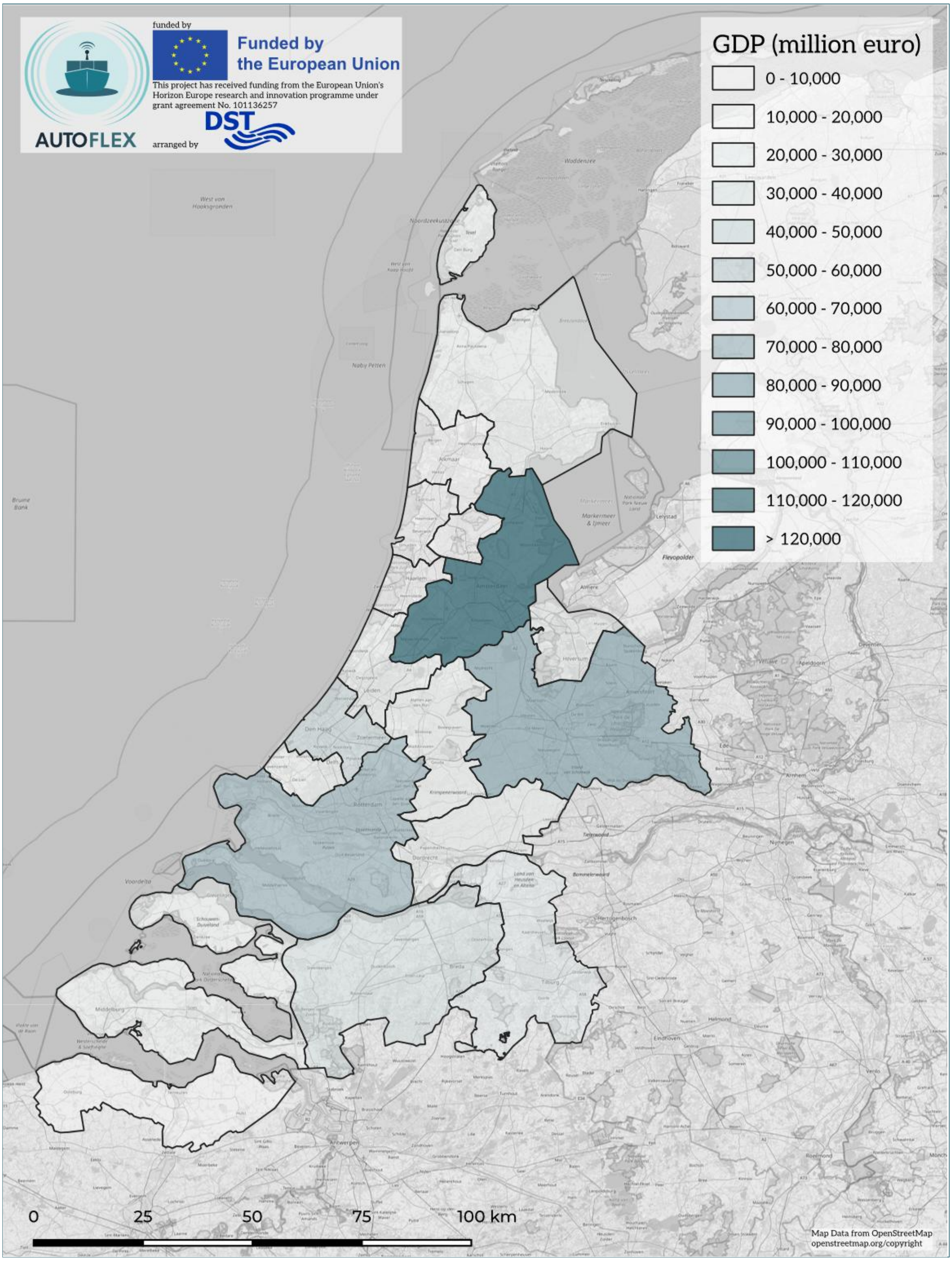

Figure 2-5: Regional value creation in the Use Case 1 area

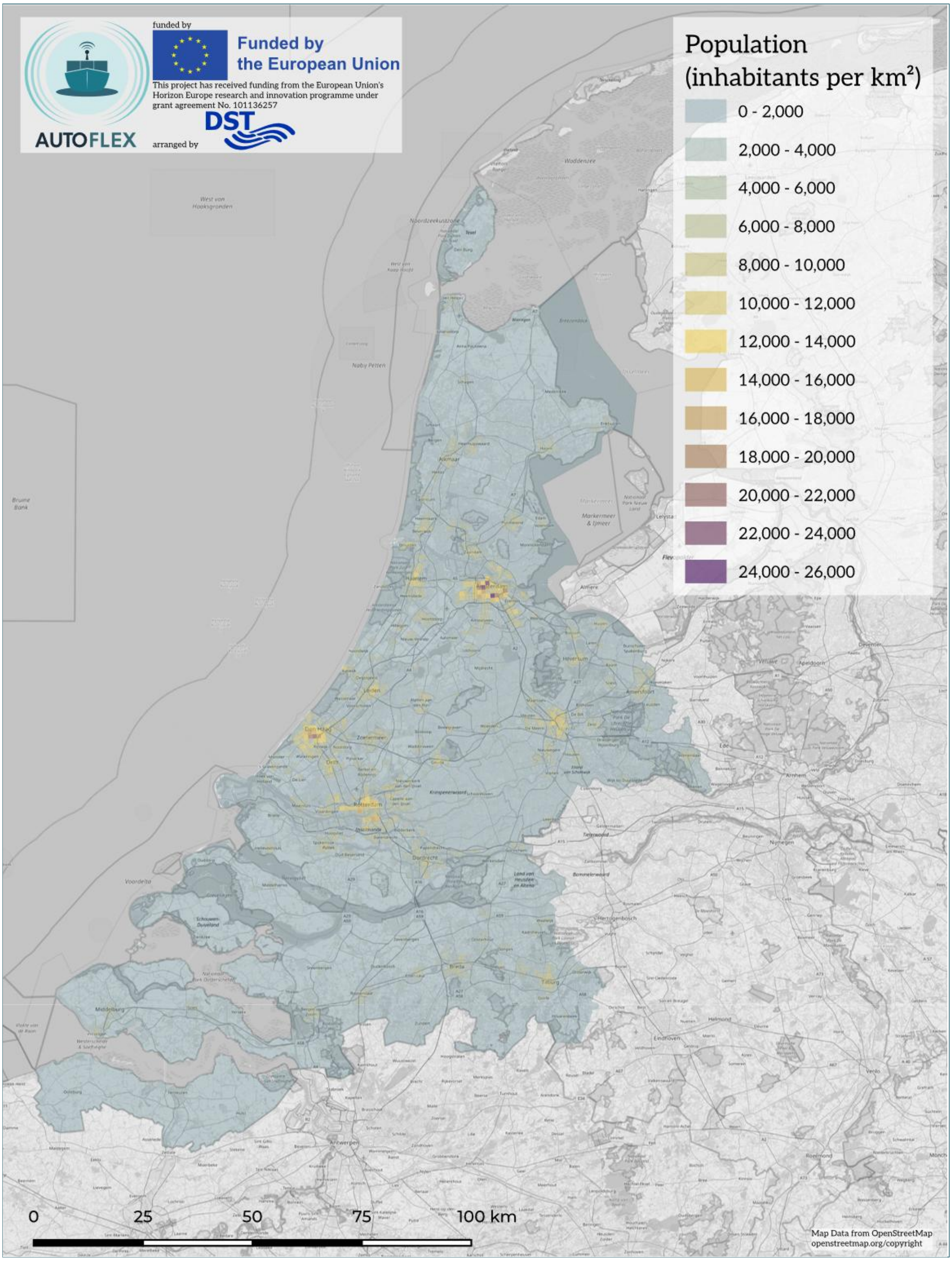

Figure 2-6: Population density in the Use Case 1 area

2.2 USE CASE 2: THE GHENT ZERO-EMISSION TERMINAL

2.2.1 USE CASE FOCUS

With a dense waterway network and several seaports in the Belgium and the Netherlands, to which Rotterdam and Antwerp as the two largest European seaports belong, the region qualifies for a second use case. Similarly, the economic activity and the density of logistics services in the region induce a significant amount of cargo which is already moved on the waterways passing through the areas surrounding Rotterdam, Antwerp and Ghent. Hence, a use case area in northern Flanders appears promising, particularly due to its network of smaller waterways of CEMT classes I to IV.

In spite of most of the inland vessels throughout Europe using fossil fuels, the considered region with its dense network and smaller distances appears as a promising test field for zero-emission inland vessels. The expected paradigm shift lies in the significant change of the expected length of a typical voyage. Whereas larger inland vessels are typically designed for long-distance voyages, e. g., along the Rhine between Rotterdam and Basle, the AUTOFLEX project focuses on small and automated inland vessels designed for short and medium-sized distances which again have not been part of the typical IWT market yet. Shorter distances may allow for a change in propulsion technology so that battery packs facilitate the use of electric inland vessels in the setting of the considered use cases.

Thereby, these inland vessels are integrated in the new intermodal transport services like the envisioned ones in the AUTOFLEX project and are supposed to reduce the climate impact. Combined with the IWT legs, the truck legs on the first and last mile are considerably smaller in length and, thus, allow for the use of electric trucks. Currently, there is also a gap between zero-emission energy production and demand, e. g., from the transport and logistics sector, and significant variations in electricity grid load.

As part of the second use case, a concept of energy and cargo hubs, so-called Stow & Charge hubs, are to be developed. These Stow & Charge hubs are to be designed as a blueprint of efficient hubs supplying the envisioned intermodal transport system with renewable energy while ensuring efficient cargo transshipments interfacing two transport legs. As part of a transferability study, the placement of the Stow & Charge hubs in the region and the development of a network of such hubs are to be examined as part of the research project.

Precisely, the Use Case 2 area has been defined around a triangle between the Belgian cities Antwerp, Brussels, and Ghent as the region is well-endowed with a set of smaller inland waterways and features good connection to the north (in the direction of Rotterdam and the southern provinces of the Netherlands), the east (via the Albert Canal), the south (to Wallonia and northern France), and the west (to the seaports along the Belgian North Sea coast) as can be seen in Figure 2-3. In order to ensure connectivity to the most relevant waterways in the considered region, which includes the Ghent-Terneuzen Canal, the southwesternmost province of the Netherlands, West-Noord-Brabant, situated south of Scheldt river and adjacent to the Belgian provinces of Antwerp and Oost-Vlaanderen, has been added to the Use Case 2 area.

Ghent has been selected as the focus point with respect to the blueprint design of a Stow & Charge hub whereas the entire use case area can be considered for the subsequent introduction of an intermodal transport service using small, flexible, automated, zero-emission inland vessels.

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2.2.2 USE CASE AREA

According to the above-mentioned focus on northern Flanders and the Flemish waterway network with its smaller waterways, the following NUTS-3 regions have been included in the consideration:

- BE10 (Région de Bruxelles-Capitale) with
  - BE100 (Arrondissement administratif de Bruxelles-Capitale),
- BE21 (Prov. Antwerpen) with
  - BE211 (Arr. Antwerp) and
  - BE212 (Arr. Mechelen),
- BE23 (Prov. Oost-Vlaanderen) with
  - BE231 (Arr. Aalst),
  - BE232 (Arr. Dendermonde),
  - BE233 (Arr. Eeklo),
  - BE234 (Arr. Gent),
  - BE235 (Arr. Oudenaarde) and
  - BE236 (Arr. Sint-Niklaas),
- BE24 (Prov. Vlaams-Brabant) with
  - BE241 (Arr. Halle-Vilvoorde),
- NL41 (Noord-Brabant) with
  - NL411 (West-Noord-Brabant).

The above-mentioned NUTS-3 regions in the central part of Flanders and southwestern Netherlands belong to the selected Use Case 2 area (see Figure 2-7).

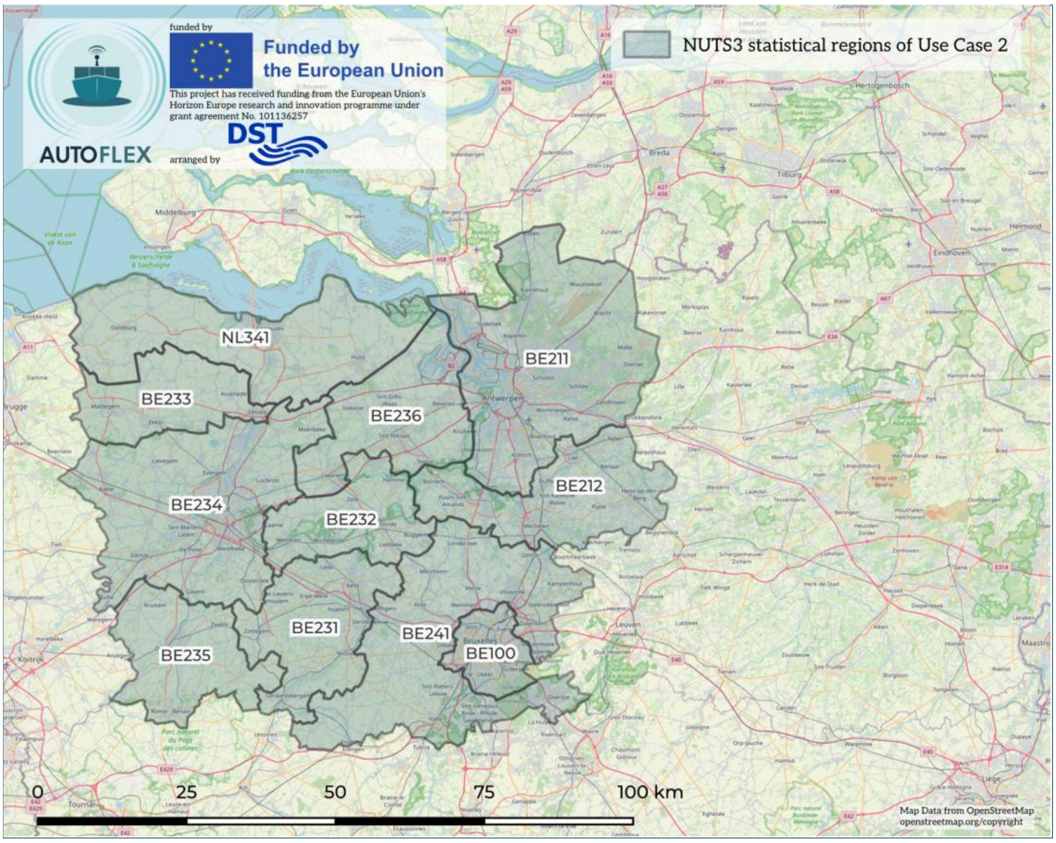

Figure 2-7: Service area of Use Case 2 (Belgium and the Netherlands)

As the region lies between large seaports along the North Sea coastline of both Belgium and the Netherlands and accommodates large seaports itself, it qualifies for the deployment of a waterborne transport service. These regions vary in economic value-creation and population density, with Brussels, Antwerp, and Ghent topping the list in both categories.

Based on the data for the year 2021 from EuroStat, the regional disparities between the regions in the considered areas appear rather huge with the Brussels region exhibiting double the regional value creation of the second-lying Antwerp province and four times the volume of third-ranked Oost-Vlaanderen centring the city of Ghent (Eurostat, 2024a, 2024b). Figure 2-8 presents the value creation of the different NUTS-3 regions involved.

With respect to population density acc. to EuroStat data of the year 2021, the Use Case 2 area includes an extraordinarily densely populated area around the Brussels-Capital Region, a densely populated city of Antwerp, the city of Ghent and a few smaller cities with elevated numbers of inhabitants per square kilometre (Eurostat, 2023, 2024a). Figure 2-9 features the population density in the considered regions of Belgium and the Netherlands.

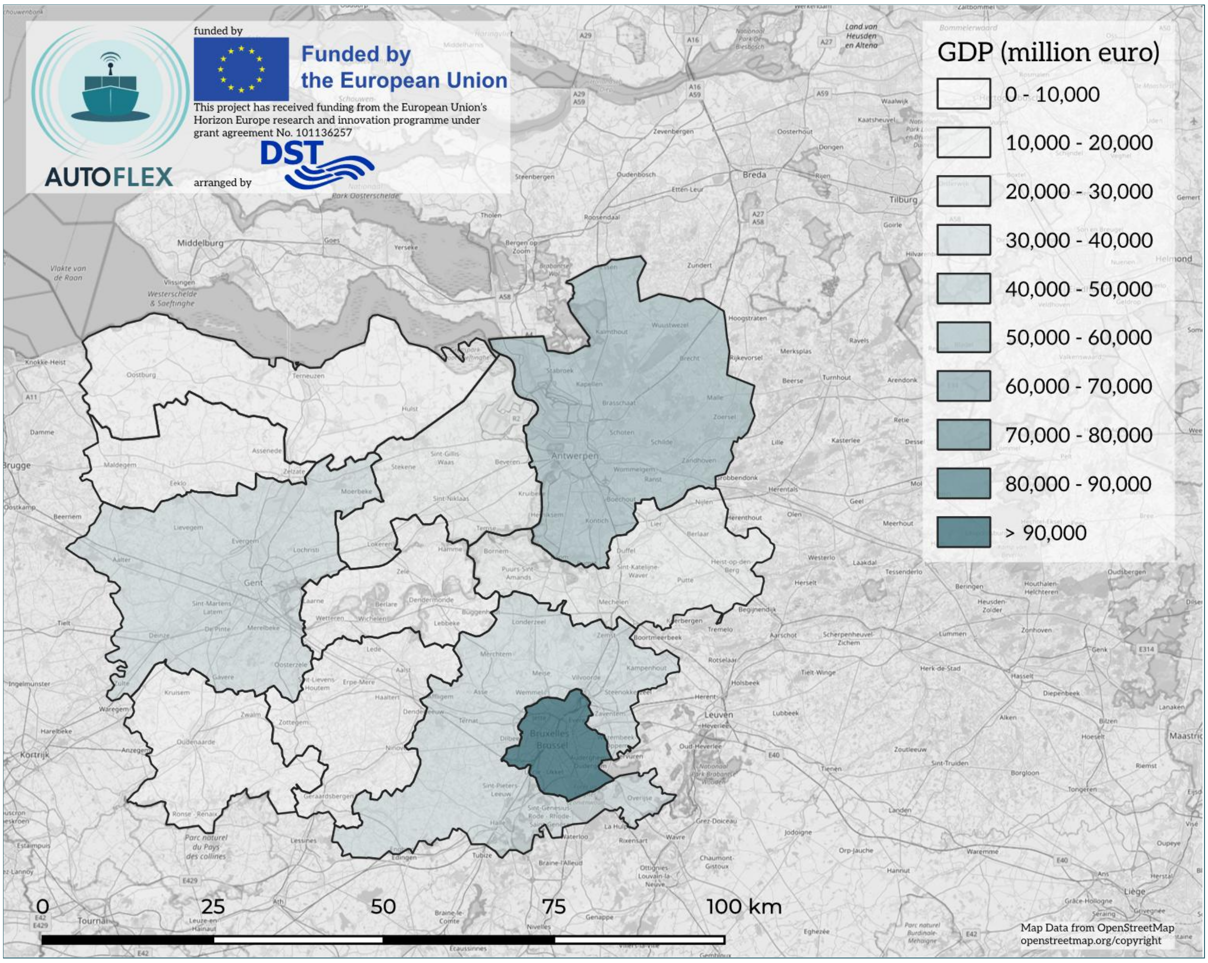

Figure 2-8: Regional value creation in the Use Case 2 area

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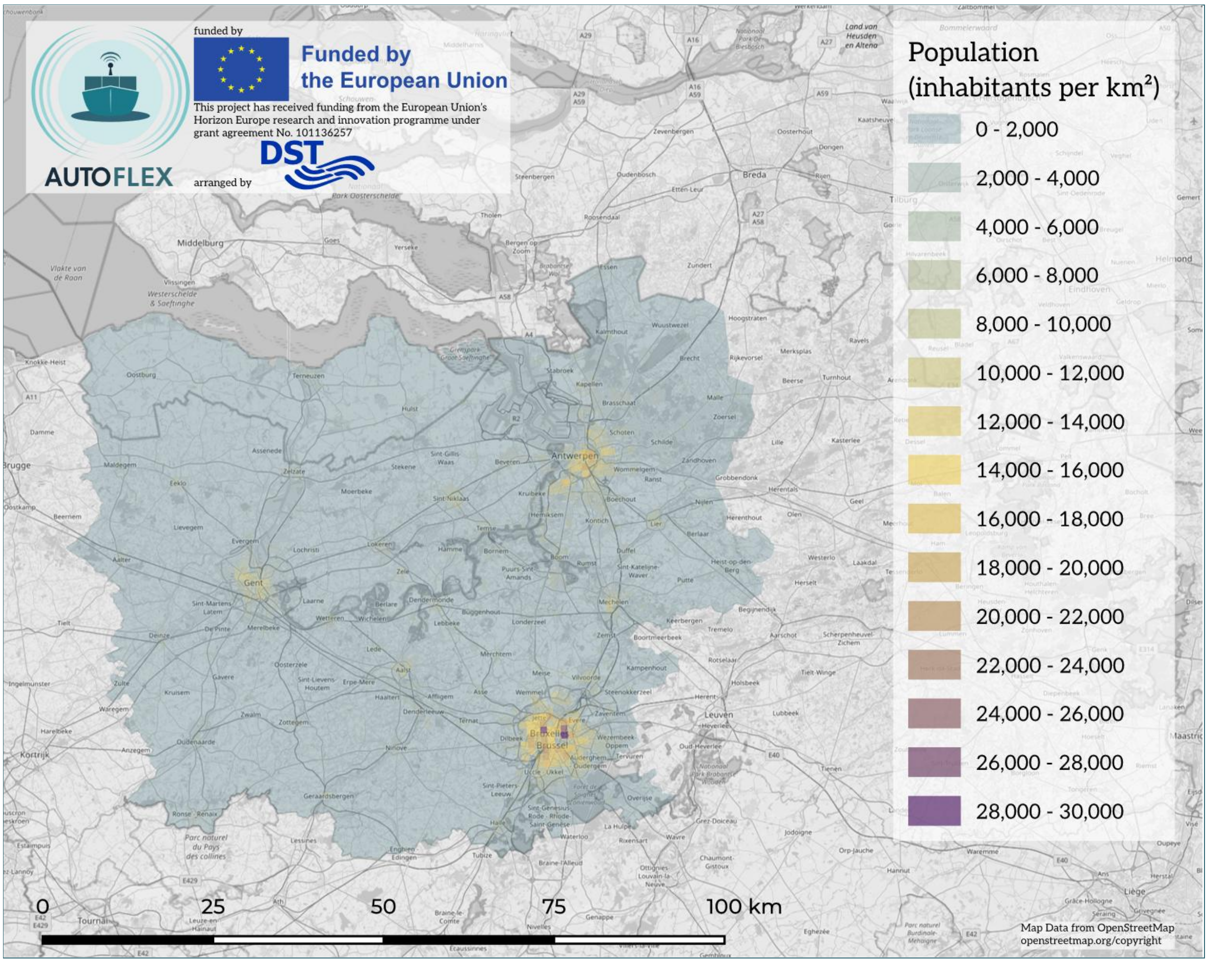

Figure 2-9: Population density in the Use Case 2 area

3 DATA REQUIREMENTS FROM OTHER WPS

As described in section 1.1.1.1.3, the collection of geographic, nautical, technical, and economic information about the use case areas and the potential operation of a waterborne transport service lies in the focus of task T2.1. Apart from the information about waterways, hydraulic structures, and further waypoints, the focus lies on times, costs, probability and frequency of occurrence, statistical variation and other market-related parameters.

The work on the design parameters of both the envisioned transport system and the novel inland vessels as well as on the underlying use cases is not an end in itself. Instead, it is supposed to provide a framework for the precise identification of requirements and boundary conditions. These requirements and conditions then need to be taken into consideration during the above-mentioned design work. Therefore, the precise information requirements of the different work streams of the AUTOFLEX project have been scanned and scrutinised. According to those information requirements, a list of expected data and relevant requirements is collected as input parameters to the respective design processes. In the following, the main information requirements from the different work streams are presented.

3.1 INPUT TO THE DESIGN OF INLAND VESSELS AND TRANSPORT SYSTEMS

From T2.4 and WP 2, the precise cargo transport demand is required to model the transport demand in a simulation-based evaluation tool like SIMPACT (Tangstad, Nordahl, Kisialiou, et al., 2023). Precisely, a set of cargo “producers” and “consumers” representing a door-to-door freight transport case is required to model the intermodal transport chain including the waterborne leg on the Dutch and/or Flemish waterways. To the data about the producers and consumers belong the respective location data and further descriptive information about the producer and consumer companies, the terminals involved, and the transport demand in freight volume per time unit. Typically, the producer and consumer are considered as origin and destination of a multimodal transport in the SIMPACT environment whereas terminals are locations for cargo transshipment between two transport legs possibly using two different transport modes. As to the transshipment locations, the existing infrastructure (including available space and transshipment facilities) and the suitability for the installation of a Stow & Charge hub, the establishment of a local power production and the provision of future charging infrastructure – next to the handling and intermediate storage of containers – needs to be scrutinised.

The arcs used for travel between the above-mentioned nodes, such as producers’, consumers’ and transshipment locations, are waterways and roads, respectively. Whereas the network data for commercial road freight transport is mostly publicly available on local, regional, national, and European level, the situation is more complicated with the waterways – despite the above-mentioned EuRIS portal. The CEMT class of the inland waterways and the maximum permissible dimensions of an inland vessel sailing on a particular waterway stretch are already available in the public portal. The differentiation between canals (as controlled waterways) and rivers (as free-flowing waterways), the

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applicable speed limits, the tidal influence or dependency, and the applicable wavelength thresholds have a direct influence on the vessel design process. Further details of the inland waterway, including its course, its dimensions, and its geometry, at a suitable resolution remains a desirable asset in order to model the waterway in such a way that determining a realistic energy-consumption of a particular inland vessel sailing a particular inland waterway is enabled.

Along the considered waterways and terminals, information about the berths need to be collected as well, particularly their geo-location, size, and maximum permitted vessel dimensions. Particularly in case of berths belonging to a transshipment point, the details are of significance for the further course of the research project in order to combine it with (existing or future) transshipment facilities for the deployment of temporary port terminals and mobile distribution centres. While the latter may encompass existing berths with temporarily available transshipment facilities or even temporary berths (e. g., combined with shoreside transshipment facilities), the latter refers to the vessel acting as a distribution centre or to any structure or cargo-carrying container unit that is stowed and carried in the vessel.

In addition, the geo-location of bridges and locks along with additional information of these structures on the waterways, such as type, dimensions, and clearance profile details, need to be collected.

With respect to locks, the average time to pass a lock, the variation of the passage time due to the heterogeneity of the different locks, and the properties of a lock impacting the passage time are in the focus of interest. Since earlier studies of lock operation and lock passage have revealed that statistical variation does occur with inland vessels passing a lock due to different traffic and usage patterns related to that lock, the phenomenon needs to be considered in the modelling of the transport system (Glerum, 1983; Terlouw, 2015; van Adrichem, 2020).

Similarly, the passage time of bridges need to be determined, particularly those of movable bridges with operation times. Next to the passage times, the statistical variation, the differences in passage times depending on the bridge type and further properties impacting the bridge passage time are of interest. In addition, the passage of bridges becomes a particularly sensitive issue when discussing waterborne container transport with multiple transport layers. The bridge clearance height needs to be defined in such a way that the draft of the vessel and the required margin between the top container layer and the bridge structure are considered.

3.2 INPUT TO SIMULATION-BASED LOGISTICS ANALYSIS

Apart from the design of the inland vessels and the waterborne transport system, the AUTOFLEX project foresees a simulations-based examination of the logistics flows in the envisioned transport system and its performance in terms of economic, environmental, and social dimensions.

In order to evaluate the logistic and energy key performance indicators (KPIs) for the AUTOFLEX transport system in the SIMPACT software, there is a need to expand some already existing simulation models and introduce some new ones. Specifically, there is a need to expand the vessel model to be able to determine the air draft of the vessel for

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different loading conditions. Further, there is a need to include models for bridges, locks and other items specific to the European inland waterway network: There is also a need to create dedicated models of the AUTOFLEX building blocks, i. e., mobile distribution centres (MDC), Temporary Port Terminals (TPT) as well as Stow & Charge hub (S&C) locations. With these models in place, the AUTOFLEX transport system can be simulated with discrete event scheduling, allowing for evaluation of the long-term performance of the AUTOFLEX transport system compared to a landside and/or waterborne baseline.

3.2.1 INLAND WATERWAY MODELLING

SIMPACT already supports automatic routing where vessel dimensions are considered. This routing is based on EuRIS data. What is missing is data or models on waterway actual dimensions (not permissible dimensions), speed limits, locks and bridges. The following section will present the requirements for the models that will be implemented to support the AUTOFLEX project, either as new models or expansions of existing models.

Canals

To achieve sufficiently accurate energy consumption estimates when simulating barges traveling on the inland waterways it is necessary to extend the inland waterway route model that is already implemented in the SIMPACT tool to include the canal geometry. Additional necessary route parameters are:

- canal width
- canal depth

In the European inland waterways, canals are classified by CEMT classes describing the permissible dimensions of the vessels that operate in the canals. However, the CEMT classes do not directly inform the sizes of the canals themselves, which may vary. Therefore, there is a need for a source of canal size information. This information should be provided by authorities of the canals, such that the data informs the actual geometry of each respective canal at a certain width and depth resolution. This may not be available for a given country or canal. In this case, there is a need for a set of rules that describe the relationship between permissible barge dimensions and the minimum canal geometry.

An example of the latter is given by the inland waterway association in the United Kingdom, that describes the inland canal design minimum dimensions to accommodate a barge with width **B** and draught **D** (Iwan, 2023). Both values are calculated as follows:

- Depth of fairway: **D** + 20% or 0.3 m, whichever is greater.
- Width of fairway: 2.1 × **B** or 6 m, whichever is greater.

However, no such information has been found available for the EU inland waterways.

Bridges

Bridges needs to be modelled to determine feasible routes along the canals, and any impact which they may have on sailing times due to either speed restrictions or the need for waiting for the bridge to open. A bridge must contain the following:

- Name
- UN/LOCODE

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- Coordinates
- List of bridge channels

Bridges may have several bridge channels. Some bridges have dedicated channels that open, allowing for arbitrary air draft for the passing vessel, while they may have other channels of different heights that do not open at all. Each bridge channel must include the following:

- Height closed
- Width
- Height opened (i. a.)
- Lifting time (i. a.)

This way, a single bridge model can contain several channels with different features. The coordinate, height and width data can be extracted from the EuRIS API, while the lifting time (time it takes to open the bridge) is unknown, and would have to be input by the user. Depending on the granularity of the information available for a given region, this input can be given as input per bridge, or as an average time for several bridges in the region, that would then be applied to all the bridges in a given route.

Locks

Similarly to bridges, locks need to be modelled to determine feasible routes in inland waterways, and to account for additional time spent due to passing locks. While bridges add delays depending on the vessel air draft and width, locks add delays every time they are passed. No size consideration will be needed, except in routing where vessel dimensions will be used to find feasible routes. A lock must include

- Name
- UN/LOCODE
- Coordinates
- Time to pass
- Opening hours

3.2.2 VESSEL AIR DRAFT

Opening bridges add time to a barges voyage and has an impact on the adjacent road traffic. It is therefore important that evaluations of the AUTOFLEX transport system and vessel concept includes these aspects. The key is to detect what bridges needs to be opened, and how many times. As an example, some bridges will have to be opened if the vessel carries two stacks of containers but not if the vessel carries one stack. The vessel model will have to be expanded to facilitate height calculations for determining if a given bridge needs to be opened or not. This requires that the air draft, or highest point, of the vessel is calculated based on the carried cargo and resulting draft of the vessel. Currently, for considering logistic KPIs, SIMPACT ship models cargo holds only consider the total weight and total cargo volume at any given time of a voyage. This is not sufficient to calculate the draft and air-draft of the vessel. Therefore, the cargo holds of the ship model in SIMPACT need to be updated by adding a table relating the carried cargo-weight to the draft / air-draft.

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The air draft of the vessel will either be the height over water for the highest fixed structure of the vessel, or for the highest point of the cargo. The cargo type for the AUTOFLEX project have been decided to be containers, based on the data mapping and pre-studies done within second work package of the AUTOFLEX project. Determining the highest point of the cargo thus means that SIMPACT must know the cargo hold floor height above keel, the height of containers, and the stacking of containers.

Ship model:

- List of cargo holds
- Height of highest static object above keel
- List of cargo weight relations to draft

To relate a cargo weight to a given draft the following is necessary:

- Cargo weight
- Draft

New cargo hold parameters:

- Cargo hold deck height above keel
- List of stacks

Each stack is described by:

- Amount of cargo in stack
- Height of stack

New vessel model functions:

- Calculate height of container stack above cargo hold floor
- Calculate draft due to total cargo weight
- Calculate air draft from vessel draft and resulting cargo hold floor position relative to water level, and height of container stack.

3.2.3 STOW & CHARGE HUBS

Stow and charge terminals are terminals that have local production of zero-emission energy, and facilities for charging vessels or battery containers. The concept also includes a coordination of supplying vessels with energy and transhipment of cargo. They also typically have a connection to truck transport.

To simulate stow and charge terminals, SIMPACT needs to be updated to handle containerised batteries. This will require a new model type “energy container”, an update of the SIMPACT cargo hold model, new logic related to energy container logistics, and some updates of the simulation configuration.

- Energy container model
    - Energy capacity
    - State of charge/energy
    - Charging rate

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  - Weight
  - Dimensions
  - Position (in cargo hold, or at terminal)
- Logic for deciding to swap energy container
  - Threshold for container charge to decide to load it
  - Threshold for deciding to replace a container that is currently on the vessel
- Configuration of initial state (how many energy containers are in the system, and at what locations are they placed at start of simulation?)
- Cargo hold model update: capacity considers container type (e.g. a cargo hold could be dedicated for energy containers)

3.2.4 MOBILE DISTRIBUTION CENTRES

The MDC as a cargo unit requires a minor update of the existing cargo models. What is new is that this type of cargo does not end its journey at the consumer. Instead, it is emptied and returned to the Stow & Charge hub. In the case of a small vessel acting as an MDC, this is solvable without changes because it can be modelled as loading one or more cargo units to the small vessel, configuring the vessel as having cargo handling equipment and adjust the cargo handling time of that equipment to simulate the time the MDC-vessel would be staying at the location.

In the case, the MDC is a container or trailer, transported and left at a location, some updates are needed. Firstly, the cargo unit model is updated with a flag "Is MDC". When this flag is set, two additional input parameters are enabled, "Minimum time at location" which sets the minimum time that the MDC will be available for picking up parcels or smaller units. The second input parameter is "Weight" which is the MDC weight after parcel and smaller cargo unit distribution is done.

Finally, the consumer model must be updated such that when an MDC is consumed, an empty MDC with weight "Weight" is produced after time "Minimum time at location" has passed.

3.2.5 HINTERLAND LOCATIONS AND TRUCK SUPPORT

The AUTOFLEX transport system aims to minimize the last mile truck transport. To evaluate the systems performance against a truck benchmark, as well as to handle last mile associated with the AUTOFLEX transport systems, truck transport needs to be accounted for. Locations in SIMPACT are currently restricted to port side, or waterborne coordinates. This will need to be extended to consider the last and first-mile transport. In extension of this, truck transport from and to these locations must be implemented.

There also needs to be support for transporting cargo between the hinterland locations and port by truck. To support hinterland locations, the following must be included:

Truck model:

- Cargo capacity
- (Optional) Size

Hinterland location:

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- Coordinates
- Type (Producer or consumer)

From the hinterland location, cargo can be transported to terminals. Between hinterland and port there needs to be support for routing that allow for this transport to be performed by the truck model. Therefore, there needs to be routing established between the locations. There are several services online for automatic routing. The routing service must be able to provide the following:

- Shortest route
- Distance
- Drive time

Optionally, if it's available, it would be preferable if the routing API could take the optional truck size parameter and provide a realistic route for such a truck carrying a specific load of cargo.

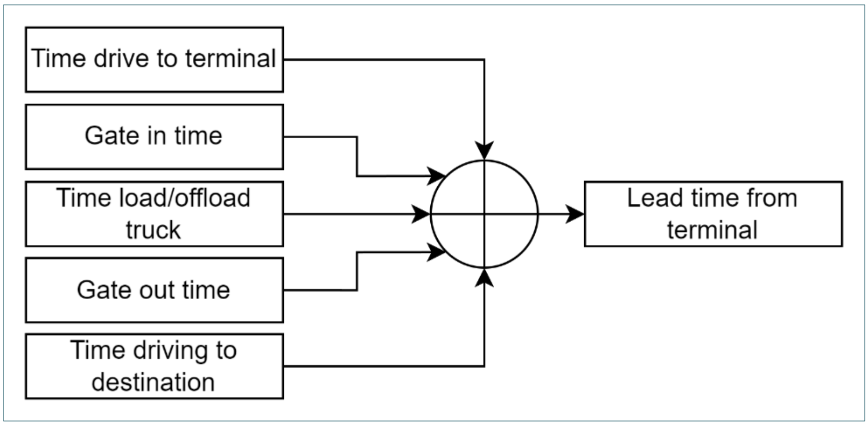

Figure 3-1: Composition of lead time from terminal

3.2.6 TEMPORARY PORT TERMINALS

Temporary port terminals can be modelled in the tool as any location using producer, consumer or terminal models that already exist. Temporary port terminals will feature similar parameters like the other models, particularly the terminal models.

3.2.7 STOCHASTIC EVENTS

Stochastic events mainly refer to the occupancy of different infrastructure resources, such as waterway stretches, locks, and bridges. However, data about such events, their frequencies, or their likelihood of occurrence is not publicly available. Their potential impact on the travel time, e. g., by waiting times incurred or downtimes of transport infrastructure, is limited as such event rarely take place but can have a considerable effect on the operability of the infrastructure.

3.2.8 SIMULATING THE AUTOFLEX TRANSPORT SYSTEM

With the extended and new models defined, the IWW transport system can be simulated. The following section describes how each addition to the model affects the voyages a vessel performs. Particularly, the heterogeneous set of innovative elements of the envisioned AUTOFLEX transport system needs to be represented in an effective manner.

MDC logistics

MDCs are produced in the same manner as traditional cargo (e. g., containers or trailers) in a production schedule. The MDC is then transported by truck or ship to either a transhipment point or directly to the consumer. At the consumer, MDC stripping delay is added. The weight state for the MDC is then updated and the MDC is ready for pickup. The ship can then transport the MDC back to origin.

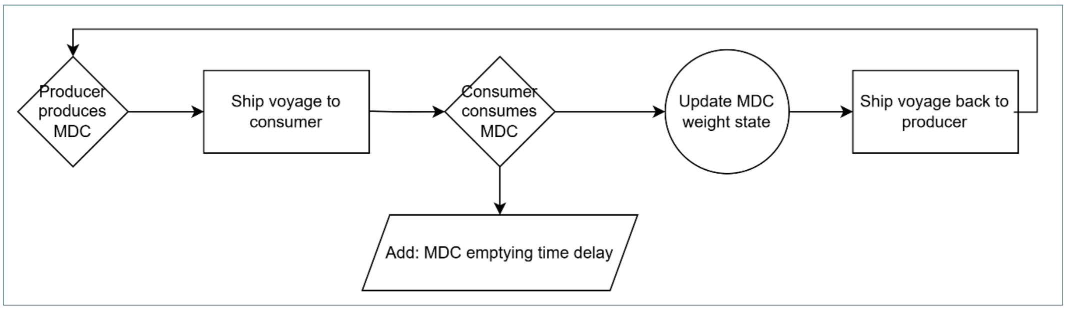

Figure 3-2: Process flow 'MDC logistics'

Ship voyage to location

The figure below describes the voyage for a ship voyage and the stages that need to be added to accommodate the MDC, lock, and bridge passing. Basically, the transport of an MDC resembles the one of a standardised ISO container (for the most part).

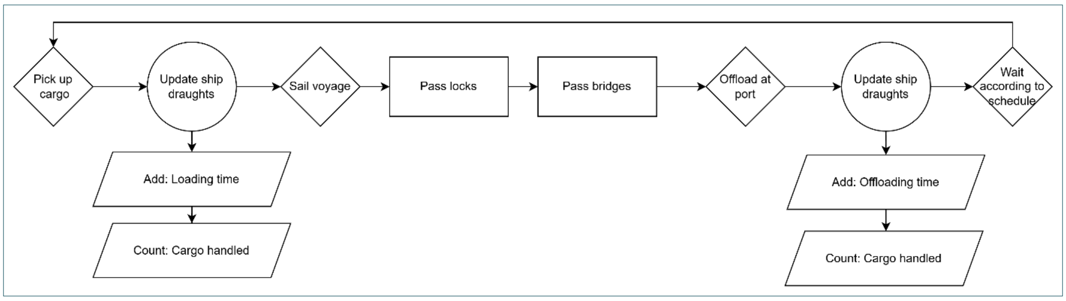

Figure 3-3: Process flow 'ship voyage to location'

Bridge passage

Passing a bridge depends on the air draught of the ship. If there is sufficient clearance, the ship can pass underneath the closed bridge, causing no delay. This is the standard case for fixed bridges and exceptionally also for movable bridges (in isolated cases). Else, the ship needs to wait with a given delay until the movable bridge is opened - and ship passage is enabled.

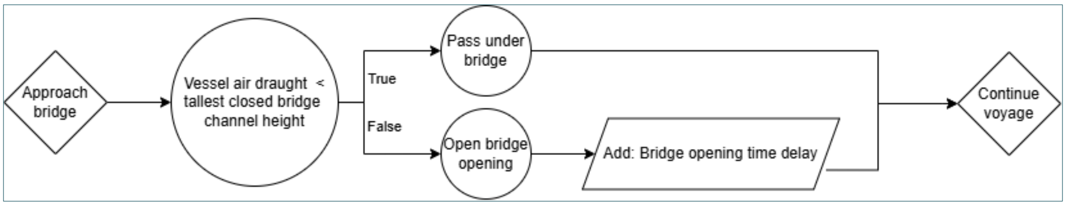

Figure 3-4: Process flow 'bridge passage'

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Lock passage

Passing a lock entails adding a lock passing delay defined either per lock or average for all locks in the region.

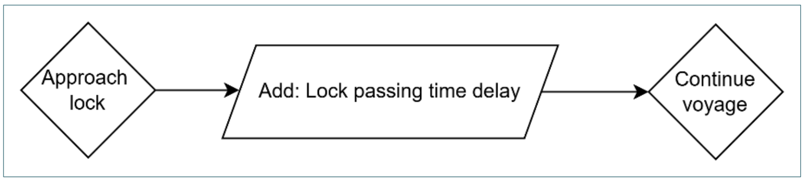

Figure 3-5: Process flow 'lock passage'

Road haulage to destination

Cargo on land will have a simpler model for transport than for waterborne transport. Time and KPIs

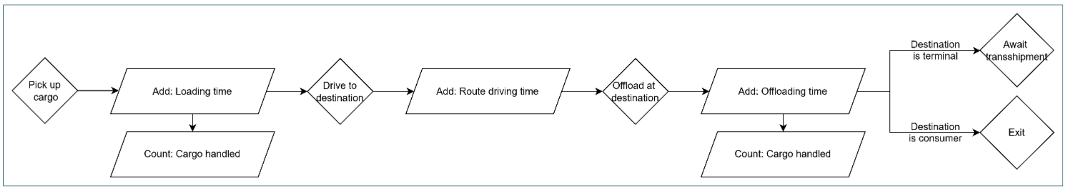

Figure 3-6: Process flow 'road haulage to destination'

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4 GEOGRAPHIC AND NAUTICAL POINTS OF INTEREST IN INLAND WATERWAY TRANSPORT

In the context of this task within the AUTOFLEX project, a point of interest (PoI) represents a geographically or nautically relevant waypoint along, in, or on the waterway affecting the transport process, e. g., a hydraulic structure, a junction, or a bridge. For a typical waterborne transport process, both the points of interest along the waterways and the ones at the shoreside need to be considered – for vessel design and operation purposes as much as for the configuration of the new service provided by the AUTOFLEX transport system. In the following, the main categories of points of interest are introduced before identifying the precise PoIs for each of the two use cases.

4.1 INLAND WATERWAYS

Principally, the term ‘waterway’ refers to rivers, canals, or lakes that can be used by ships for sailing and transporting people and/or cargo, implicitly indicating the navigability as a prerequisite to the body of water. Typically, waterways are differentiated between inland waterways and sea waterways. To the category of inland waterways, which the AUTOFLEX project focuses on, belong rivers, estuaries, and canals. Rivers can be subdivided into free-flowing and regulated river stretches (BfG, 2013; Spektrum.de).

A *river* is a natural flowing watercourse, usually carrying freshwater, flowing towards an ocean, sea, lake or another river. The ‘flow’ characteristic is the main differentiator between a river and a canal. Hence, a river typically features a certain flow velocity and naturally differentiates between upstream and downstream movement. A river starts at a spring, where water comes out of the ground, typically in the mountains, and ends at the river mouth which connects the river with the subsequent waterbody, e. g., the sea or another river. Due to the slope between source and sink, the river flows from spring to mouth. An *estuary* is a particular type and part of a river. When flowing into the sea, rivers usually flow very shallowly and slowly while depositing their sand there and forming a delta with the river dividing itself into multiple, different arms. Estuaries and their surrounding wetlands are water bodies near the river mouth at which the lower end of a river connects with an arm of the sea. Thereby, different effects occur: Estuaries typically contain brackish water, resulting from the mixture of sweet water from the river with the salt water from the sea. Next, the tide of the sea meets the current of the river, leading to different types of waves. The part of the estuary that is situated upstream of the seawater intrusion limit while still being subject to tidal motion is called 'tidal river' (Coastal Wiki, 2024).

A *canal* is a human-made, oftentimes long and thin waterway made either for ships to travel along or for taking water from one body of water to another, e. g., for irrigation purposes. While transporting water has changed in modern times due to more efficient ways, their use for waterborne transport remains vital (NOAA). As a controlled waterway, it typically has an artificially created bed of water and does not feature any natural flow.

Figure 4-1 shows the inland waterways in the Use Case 1 and Use Case 2 areas, except the ones categorized as class 0 waterways or left uncategorized. So, Figure 4-1 shows a subset

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of the waterway network shown in Figure 2-2 which again was a subset of the one in Figure 2-1.

Even more than the usual length and width dimensions and the typical course of an inland waterway, the flow velocity is a major differentiator between rivers (incl. estuaries) and canals. Most canals and channels[14] are without natural flow or feature a low flow velocity of less than 0.50 metres per second. Rivers (incl. estuaries and channels), on the contrary, feature higher and more heterogeneous flow velocities, ranging from 0.50 metres per second to 2.50 metres per second. Typically, the rivers are divided into different flow velocity categories at intervals of 0.50 metres per second. Even higher flow velocities may occur as exceptions but are not considered in the generic guidelines (Deltares, 2016; MARIN, 2018).

Both (regulated) rivers and canals may exhibit locks and ship lifts in order to compensate for too high height differences.

The official classification of inland waterways distinguishes between nine classes – mainly based on the spatial dimensions of coordinated ship types, of which the horizontal parameters of length and width are the most important. The widely known CEMT classification system has been adopted by the European Conference of Ministers of Transport (CEMT) and takes the social changes in Central and Eastern Europe into account. The aim of the classification of European inland waterways is to promote a uniform inland waterway network. The draught loaded and the fixed-point heights may vary between different inland waterway stretches, so that the draught and tonnage of the individual ship types have no direct influence on the classification (BfG, 2013; GDWS, 2022; viadonau, 2024a, 2024b).

Figure 4-2 shows the inland waterways of the Use Case 1 and Use Case 2 areas, differentiated by CEMT class. The large and famous waterways, such as the Rhine, the Meuse as well as the Scheldt offer sufficient space for class VI vessels and convoys.

Similarly, Figure 4-3 shows the rivers and canals in Belgium and the Netherlands while Figure 4-9 shows the canals in the considered geographic area exclusively. Figure 4-4 presents the tidal influence on the inland waterways in the same area. It is striking that both the Belgian and the Dutch inland waterway networks are largely dominated by canals. Particularly the region between Amsterdam and Rotterdam is endowed with a multitude of such canals (Glerum, 1983).

With respect to the tidal influence, only a few waterways, particularly leading to the big seaports in Rotterdam and Antwerp, are dependent on tidal motion. Figure 4-5 presents a detailed view of the Rhine-Meuse-Scheldt delta area including those two seaports. This means that extreme low-water events will not pose a major problem in this area. Similarly, a large part of the waterway network is tide-independent and protected from phenomena from the sea.

As a consequence, the danger of weather-related events impacting the operation on the waterways is hardly existent due to the huge number of canals and regulated waterways.

[14] *Canals* are artificial waterway linking two bodies of water whereas *channels* are natural (or modified) waterways.

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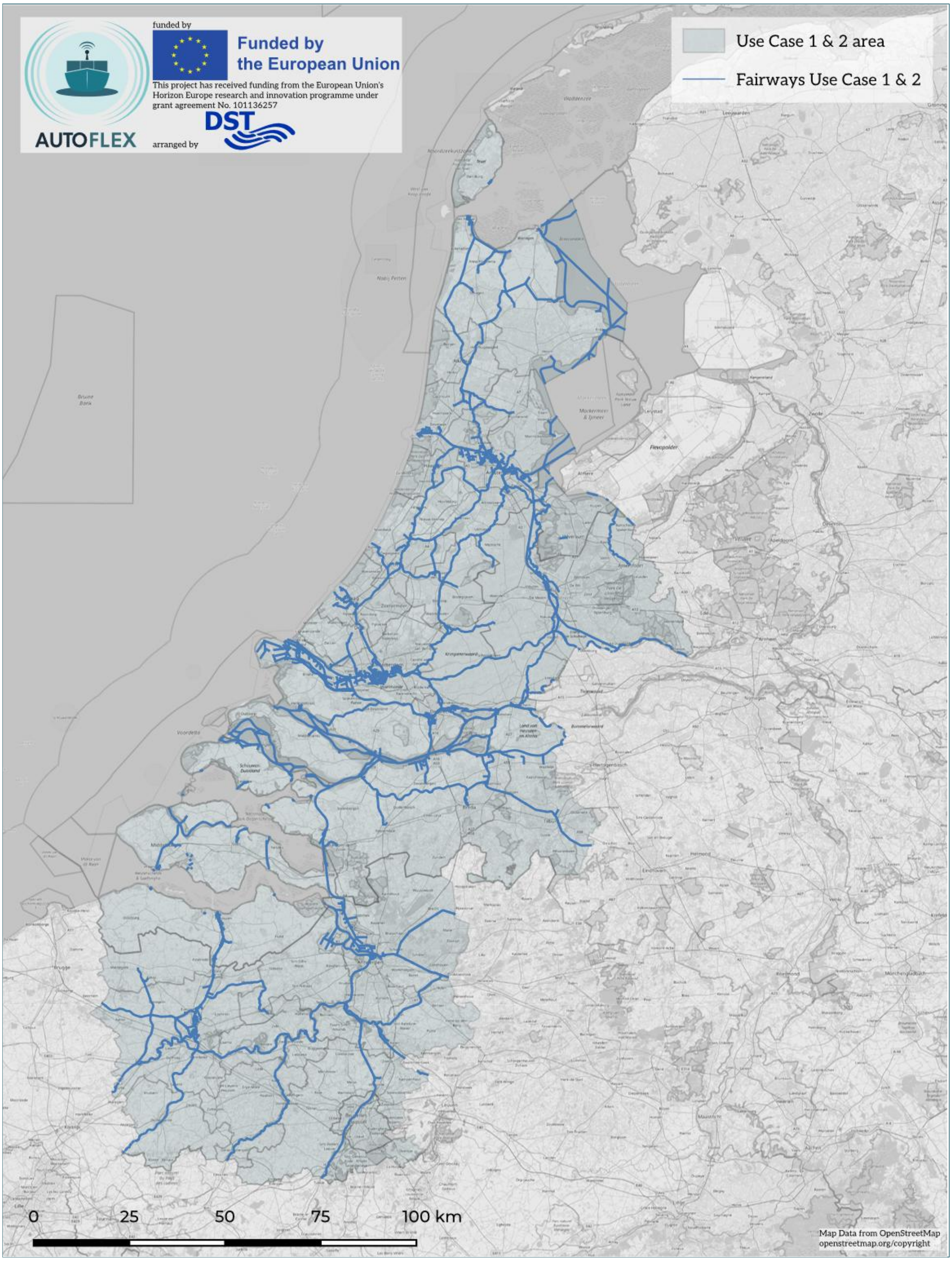

Figure 4-1: Inland waterways in the service areas of Use Case 1 and Use Case 2[15]

[15] excl. class 0 and uncategorised inland waterways

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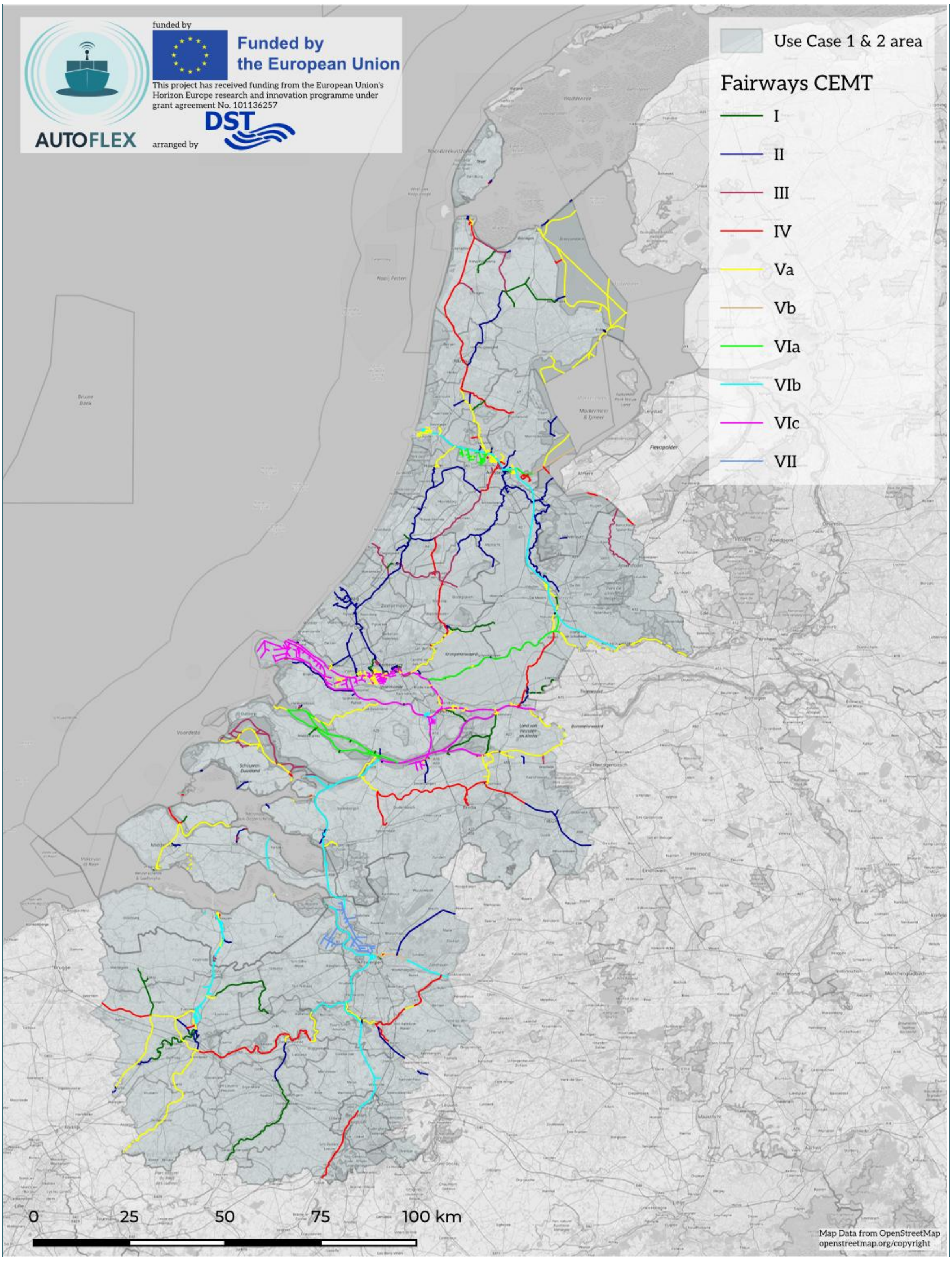

Figure 4-2: CEMT classes of the inland waterways in the Use Case 1 and Use Case 2 areas[16]

[16] excl. class 0 and uncategorised inland waterways

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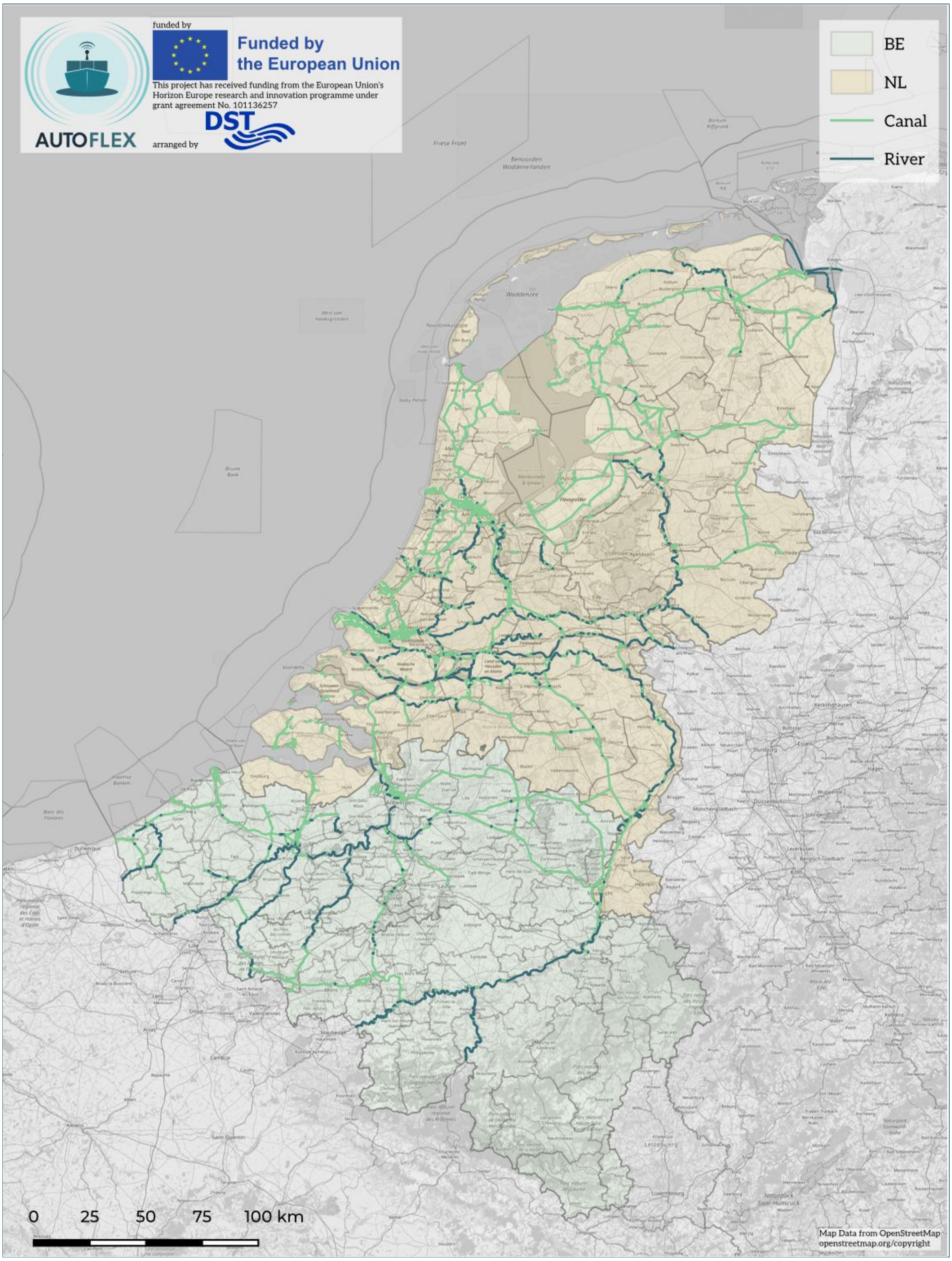

Figure 4-3: Free-flowing rivers and controlled inland waterways (i. e., canals) in Belgium and the Netherlands[17]

[17] excl. class 0 and uncategorised inland waterways

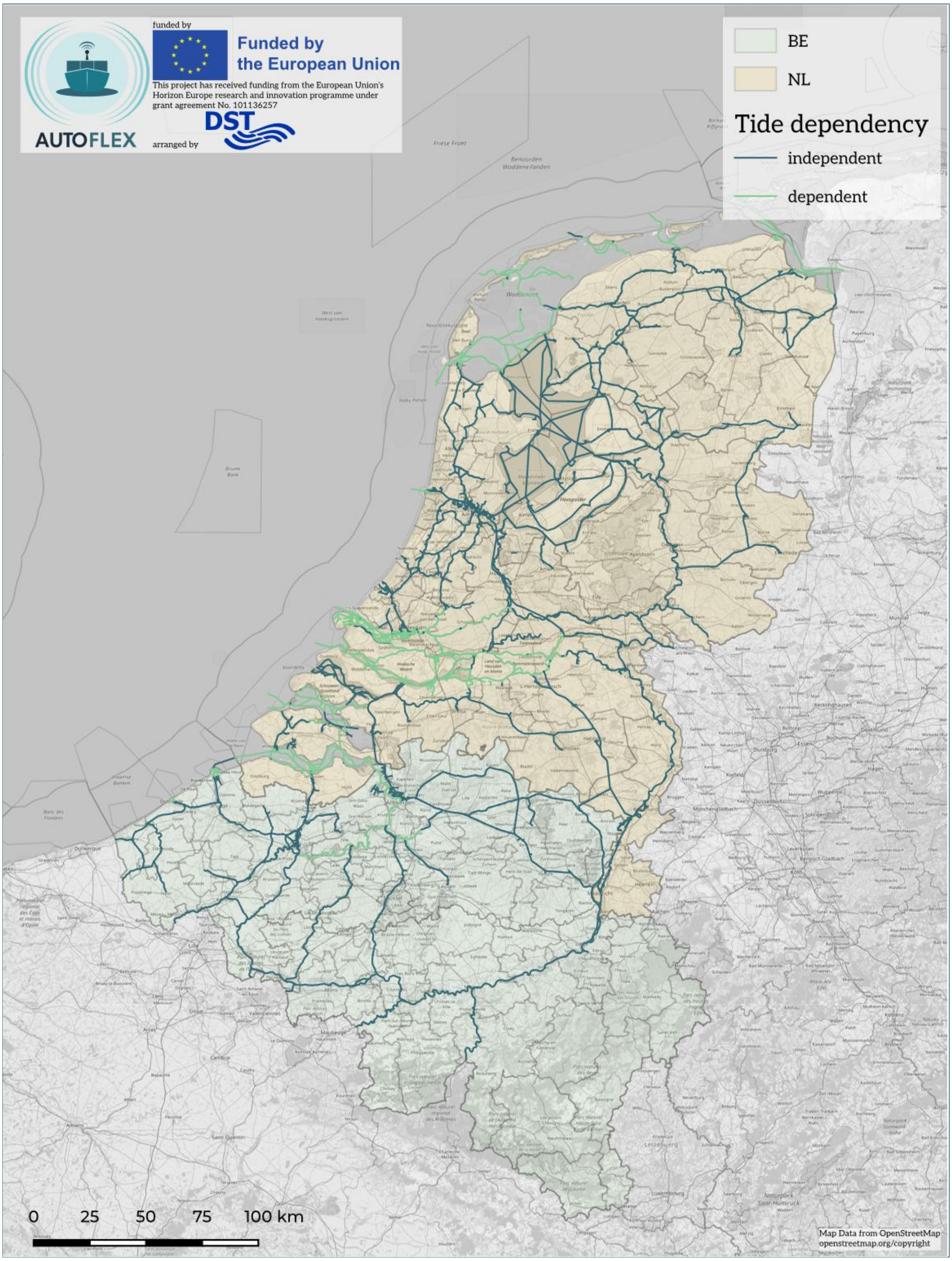

Figure 4-4: Tidal influence on the inland waterways in Belgium and the Netherlands[18]

[18] excl. class 0 and uncategorised inland waterways

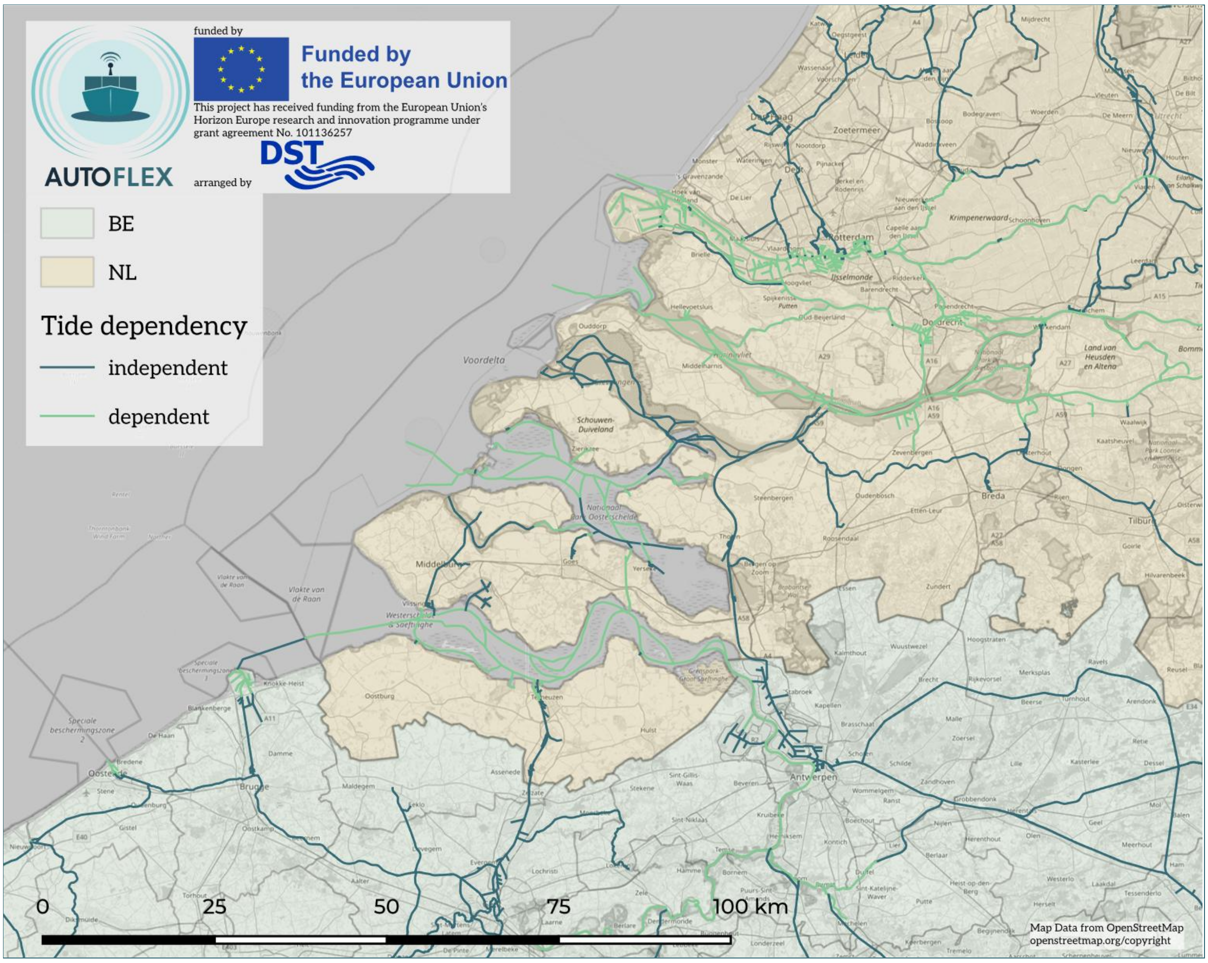

Figure 4-5: Tidal influence on the inland waterways in the area of the Rhine-Meuse-Scheldt delta

The inland waterways are categorised in four navigational zones according to the typical wave heights. In the navigational zone 1, a wave height of up to 2.00 metres is to be expected. Zone 2 includes a wave height of up to 1.20 metres whereas a wave height of up to 0.60 metres is the threshold in zone 3. All other waterways are assigned to zone 4. The different inland waterways of each country, including Belgium and the Netherlands, are assigned to one of the four navigational zones (Directive (EU) 2016/1629, 2016/Document 32016L1629; Commission Delegated Regulation (EU) 2023/2477, 2023/Document 32023R2477; UNECE, 2000, 2020).

Figure 4-6 shows the navigational zones of the inland waterways in the Use Case 1 and Use Case 2 areas. In Figure 4-7, the navigational zones in the Rhine-Meuse-Scheldt delta area are presented. It shows that the sea arms in the southwest as well as some individual waterways are assigned to zone 2 whereas a multitude of selected inland waterways belong to zone 3, and all residual ones to zone 4. Table A-1 in the Appendix lists all inland waterways in the Use Case 1 and Use Case 2 areas assigned to navigational zones 2 and 3 while none is assigned to zone 1.

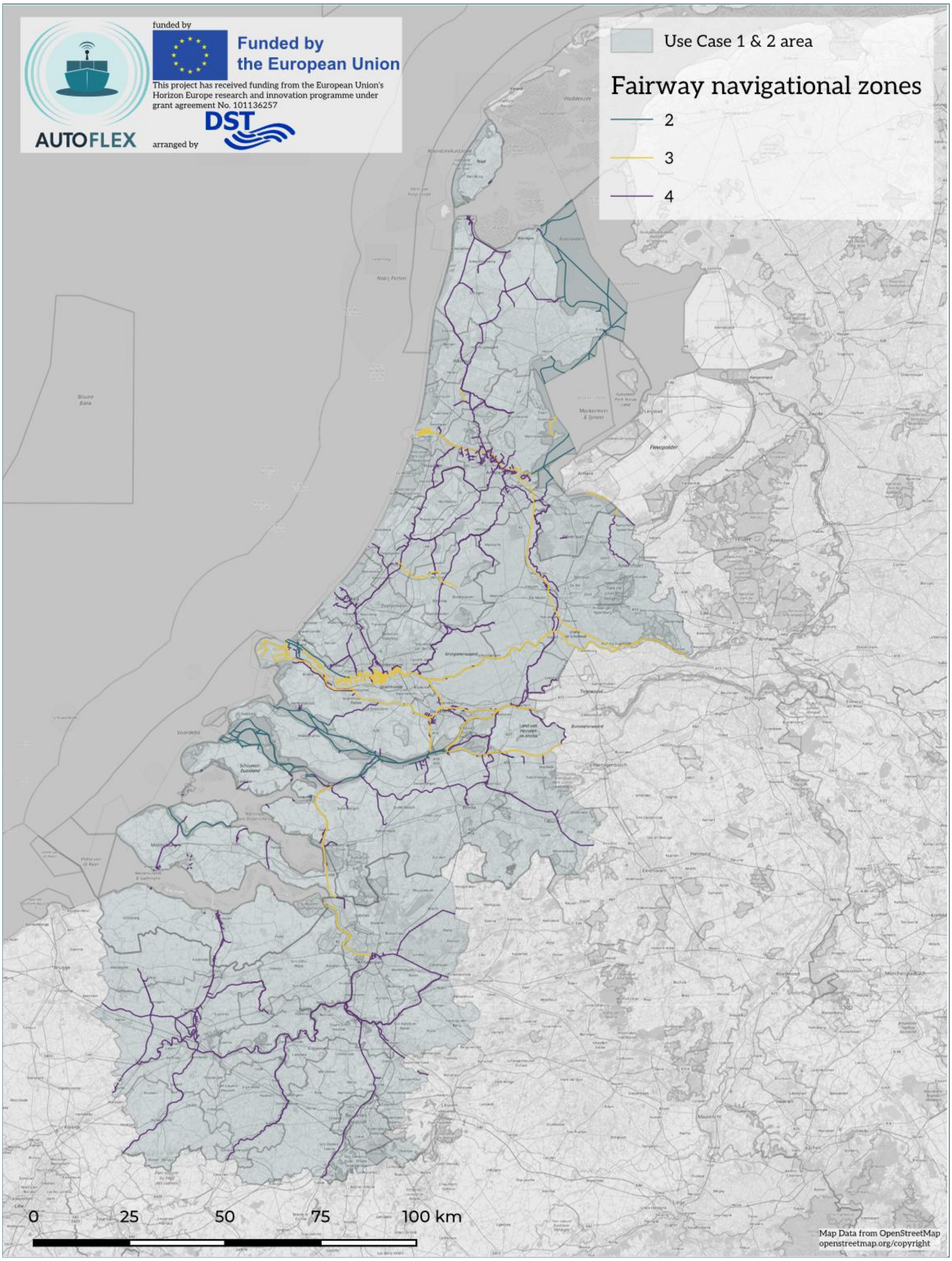

Figure 4-6: Navigational zones in the Use Case 1 and Use Case 2 areas

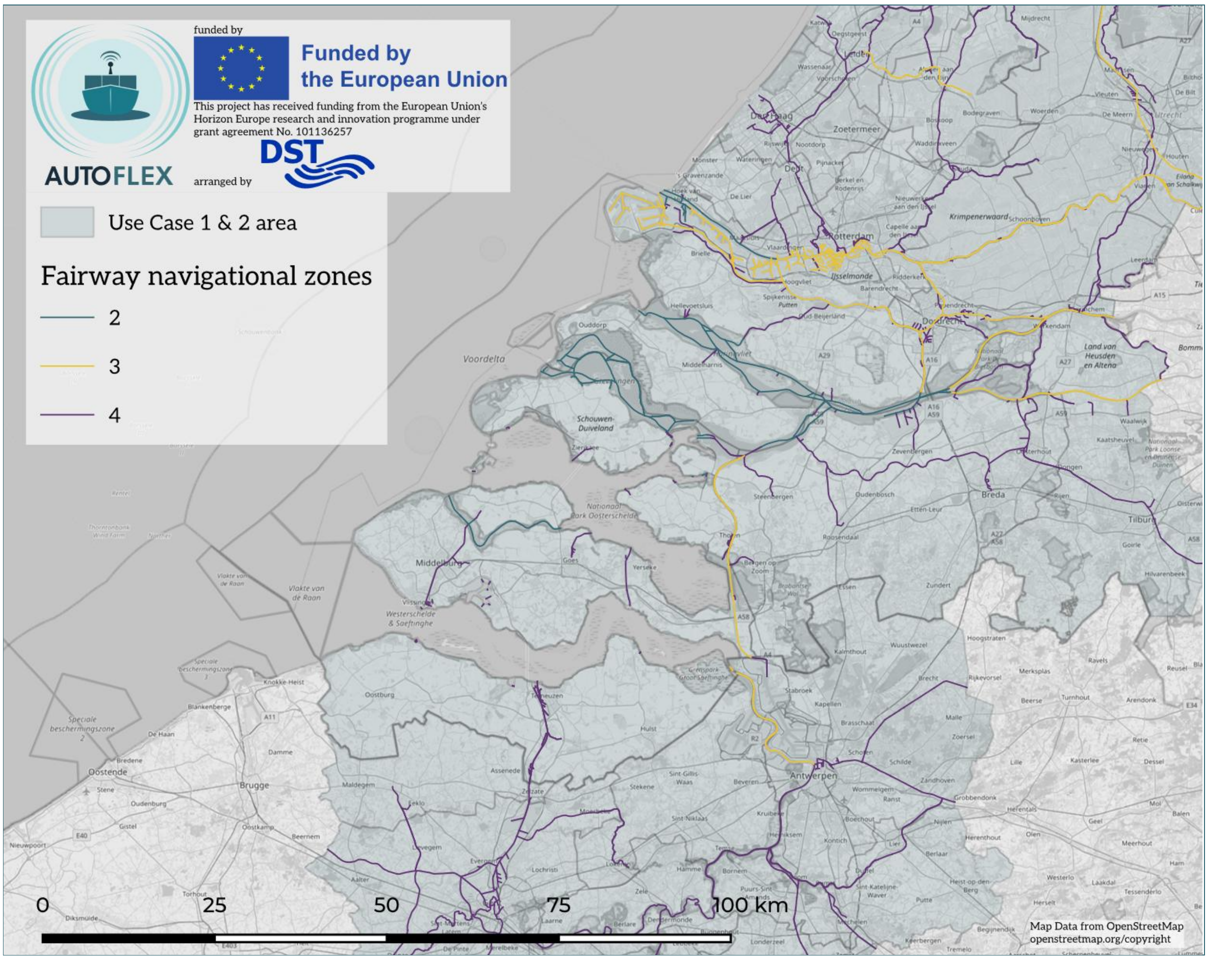

Figure 4-7: Navigational zones in the Rhine-Meuse-Scheldt delta area

The speed limits applicable on the waterways in Belgium and the Netherlands are illustrated in Figure 4-8. It has to be noted that the travel speed used for the generation of the map and for further calculations has been derived from the travel planner of the EuRIS portal[19] and represents the speed limit for downstream travel. Since downstream movement theoretically allows higher speeds with a certain energy input, these are considered as the relevant speed values. Little surprisingly, the maximum speed permitted on inland waterways of smaller CEMT classes is lower than the ones of the higher classes.

19 While the values for downstream travel were consistently available, the EuRIS portal did not provide the corresponding values for upstream travel.

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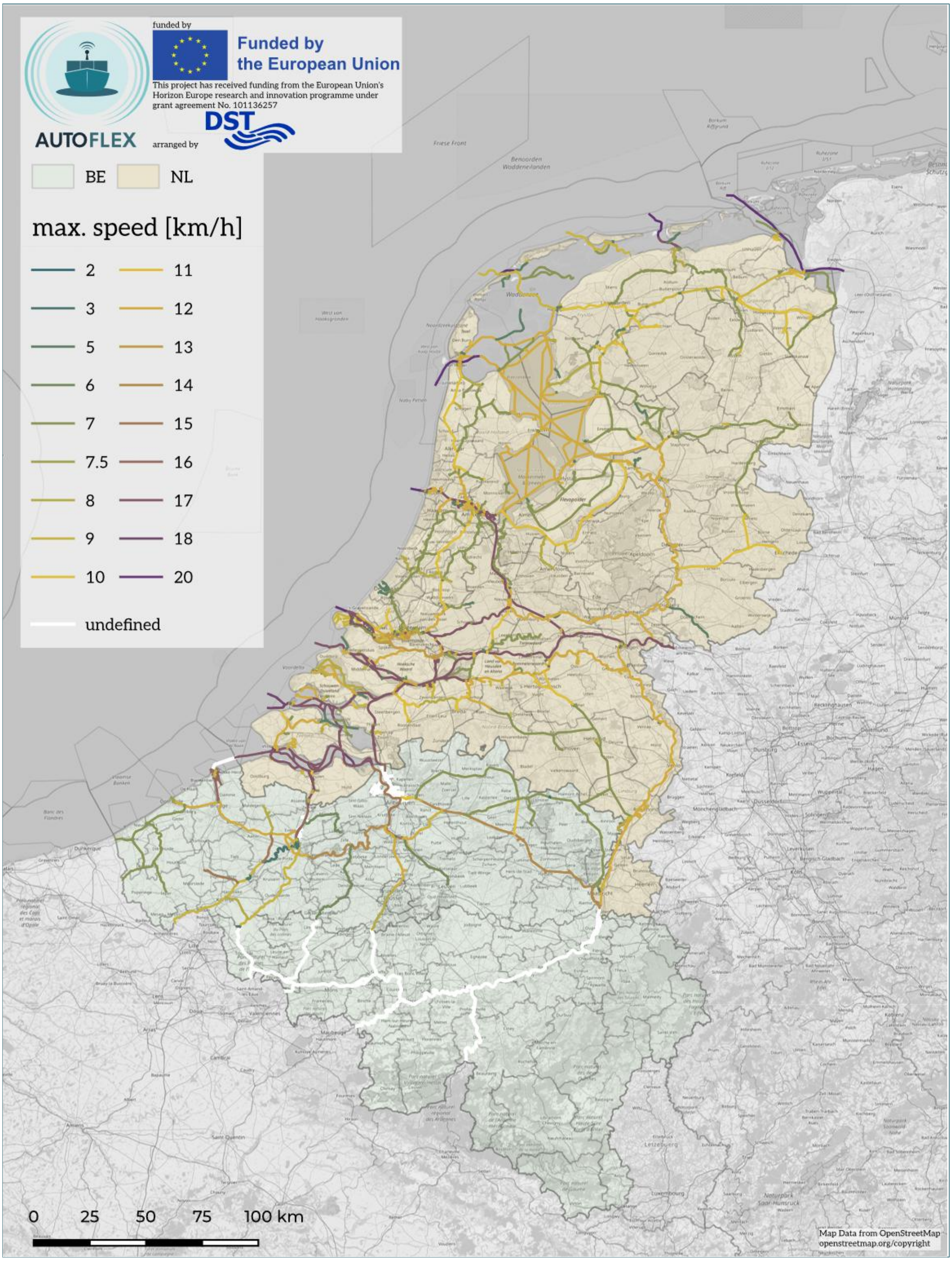

Figure 4-8: Speed limits on the inland waterways in Belgium and the Netherlands[20]

[20] excl. class 0 and uncategorised inland waterways

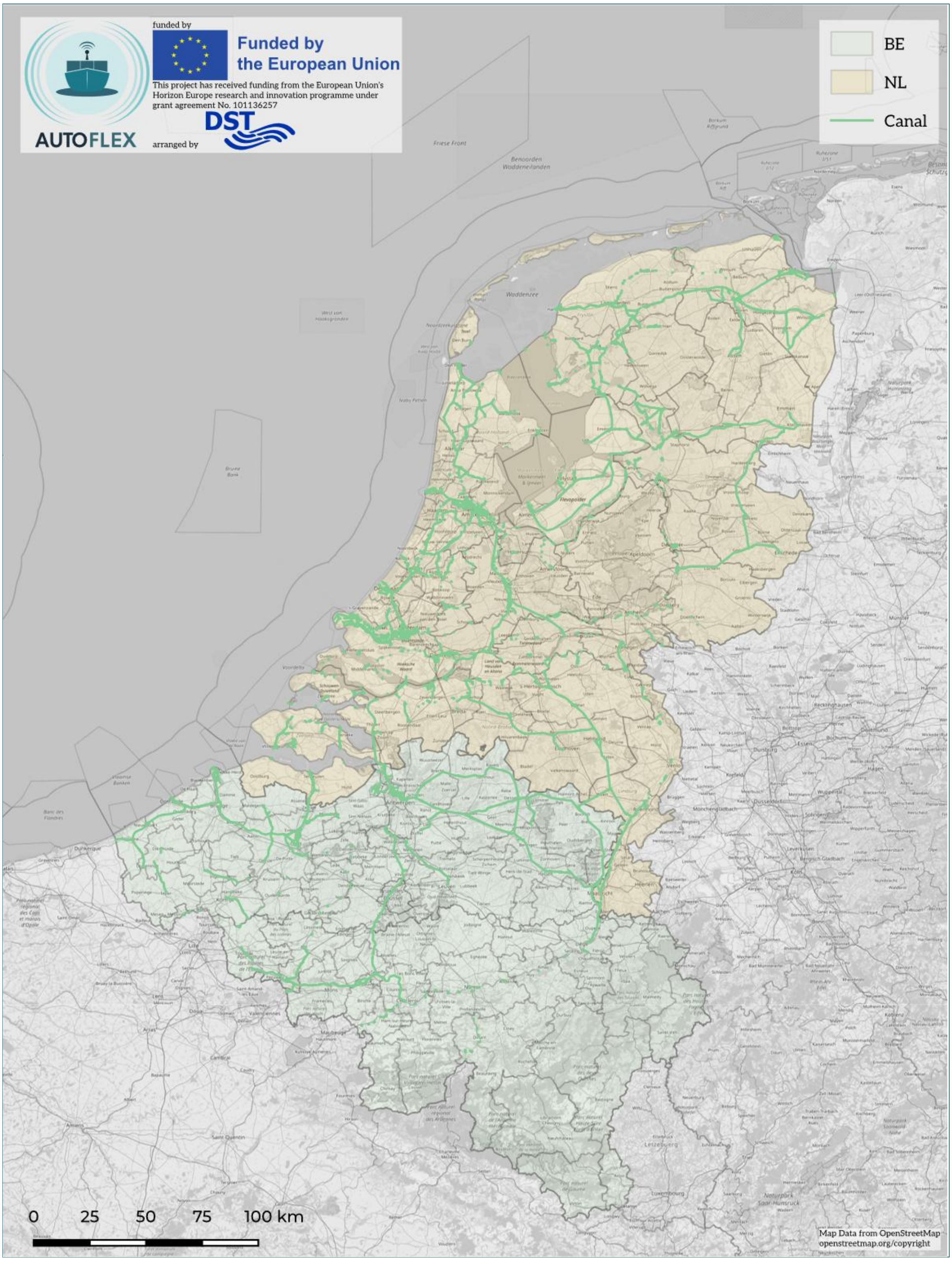

Figure 4-9: Canals in Belgium and the Netherlands[21]

[21] excl. class 0 and uncategorised inland waterways

As mentioned above and visible in Figure 4-9, the canals in Belgium and the Netherlands are numerous and run through the whole area. Since it was not possible to retrieve detailed hydrological information about the considered inland waterways including the canal profile per waterway stretch, the different profile categories are presented hereafter.

Depending on the design of the banks, a distinction is made between the following standard profiles:

- Trapezoidal profile (T profile)
- Rectangular profile (R profile)
- Rectangular trapezoidal profile (RT profile)
- Combined rectangular trapezoidal profile (CRT profile)

The trapezoidal profile features a sloping, embanked bank on both sides while the rectangular profile has a vertical bank on both sides. The rectangular trapezoidal profile exhibits one embanked and one vertical bank whereas the combined rectangular trapezoidal profile consists of a vertical bank under water in the water change area and a sloping embankment above it.

The major differences between the various profiles lie in the space requirements and the hydrodynamic properties of sailing in the canal with correspondingly different energy demands.

Unless special boundary conditions apply, the trapezoidal profile is the most economical and ecologically favourable canal profile. The T profile should be used as the standard profile wherever the more space-saving alternative profiles, i. e., R, RT, and CRT profiles, do not have to be used due to special boundary conditions.

The alternative profiles of a canal are shown in Figure 4-10 (trapezoidal profile), Figure 4-11 (rectangular profile), Figure 4-12 (rectangular trapezoidal profile), and Figure 4-13 (combined rectangular trapezoidal profile).

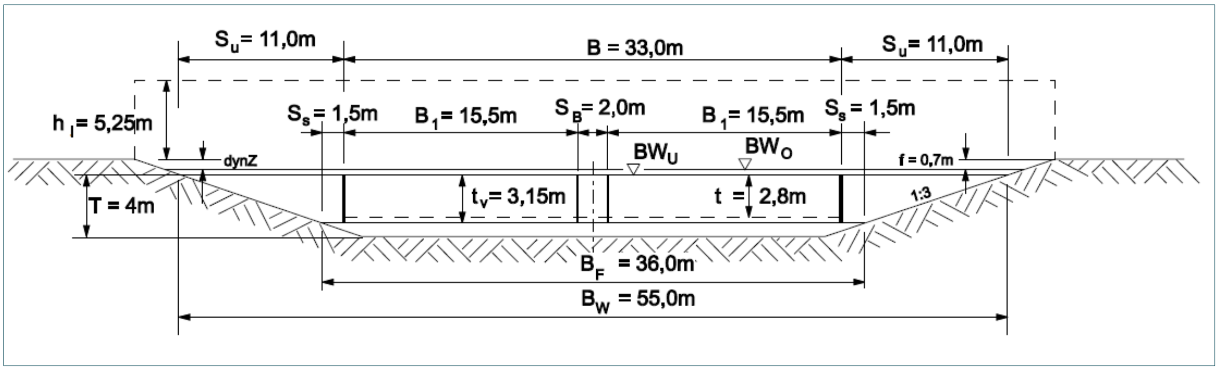

Figure 4-10: Trapezoidal profile of a canal[22]

[22] Image source: BMVBS (2011)

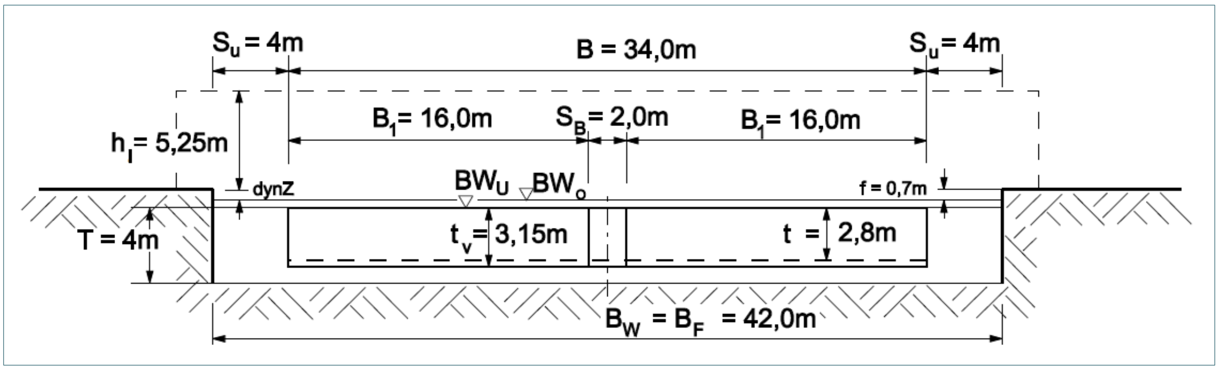

Figure 4-11: Rectangular profile of a canal[23]

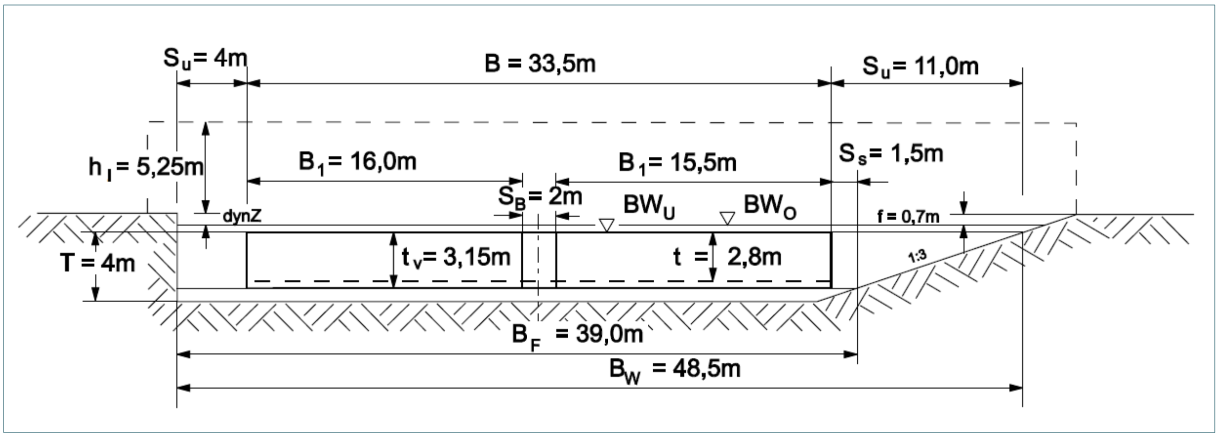

Figure 4-12: Rectangular trapezoidal profile of a canal[24]

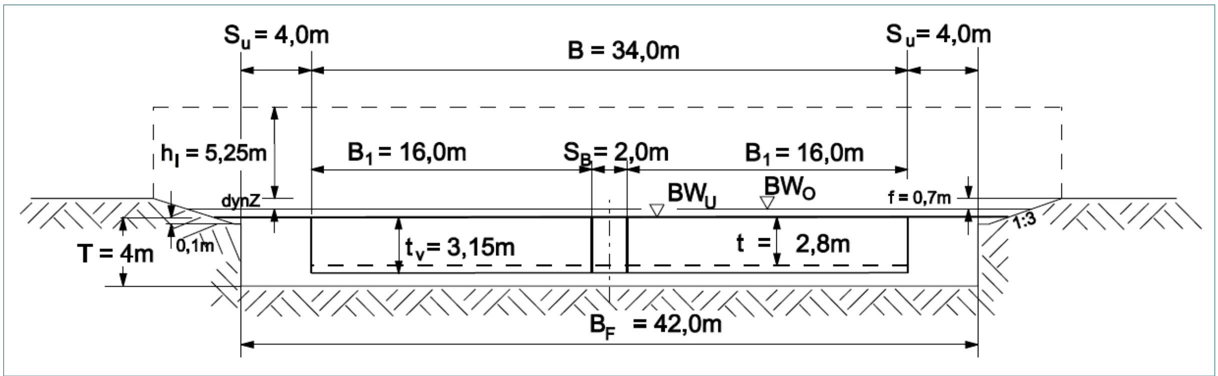

Figure 4-13: Combined rectangular trapezoidal profile of a canal[25]

4.2 BERTHS AND TRANSSHIPMENT POINTS

The PoI category of transshipment points includes all ports, terminals, and other transshipment points in the considered geographic area. Apart from actively operated ports and terminals, all (potential and current) transshipment points for a decentralized container

[23] Image source: BMVBS (2011)
[24] Image source: ibidem
[25] Image source: ibidem

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transportation network belong to the list of transshipment points. Although some of the transshipment points may not be in use anymore, they can be reactivated at reasonable efforts as they offer the (technical, spatial, and/or regulatory) prerequisites for being used for the purpose.

The RIS index differentiates between harbour area, harbour basin, port area, and terminal. A harbour basin is defined as an “area of water and land with the works necessary for its formation, protection and maintenance” (Rijkswaterstaat, 2020, p. 35) whereas a harbour basin is an “enclosed area of water surrounded by quay walls constructed to provide means for the transfer of cargo from and to ships” (Rijkswaterstaat, 2020, p. 36).

The term ‘port area’ comprises a wider understanding and “includes a city or borough with accommodations and facilities for landing passengers and goods and some amount of overseas trade” (Rijkswaterstaat, 2020, p. 37). Hence, a port may possess a harbour but a harbour is not necessary a port. According to the RIS Index Encoding Guide, a terminal is supposed to “covers that area on shore that provides buildings and constructions for the transfer of cargos from and to ships” (Rijkswaterstaat, 2020, p. 38).

As it is difficult to distinguish between these terms and the focus lies in the vessel arrival and departure as well as the cargo transshipment and handling, the terminals have been selected as relevant PoIs. In accordance with the differentiation applied in the EuRIS portal, the following types of terminals are included (Rijkswaterstaat, 2020):

- terminals for loading or unloading cars and persons used by a ferryboat (ferry terminal)
- terminals for the handling of liquid bulk cargoes (tanker terminal)
- terminals for on- and offboarding people (passenger terminal)
- terminals for container vessels and container transshipment (container terminal)
- terminals for the handling of bulk cargoes, such as iron ore, coal, etc. (bulk terminal)
- terminals for loading or unloading cars and other rolling stock (Ro-Ro terminal)
- terminals not further specified (e. g., in case the other terminal types do not apply or detailed information about cargo transshipment and handling activity is not given) (general cargo terminals)

In the following, the focus lies on container and general cargo terminals as both can be assumed as suitable locations for container transshipment (as the AUTOFLEX project focuses on container transshipment in regional scale using small, flexible, automated, zero-emission inland vessels). Furthermore, bulk terminals, tanker terminals and Ro-Ro terminals need to be considered as potential locations for the residual elements of the AUTOFLEX transport system, such as the Stow & Charge hubs, the temporary port terminals (e. g., for container transshipment in a bulk terminal), and mobile distribution centres. Passenger and ferry terminals, on the contrary, can be omitted from further consideration. Figure 4-14 shows all freight-related terminals in the Use Case 1 and Use Case 2 areas while Figure 4-15 presents the Ro-Ro terminals in the same area.

It has to be noted though that additional RoRo terminals might not have been tagged as such but as general terminals with multiple cargo types handled or erroneously as some other terminal type. For instance, the terminal in Ghent, operated by DFDS, offers horizontal transshipment opportunity with a RoRo ramp and corresponding facilities. The EuRIS portal, however, states this terminal as not further specified.

Since the effort of collecting additional information about all ports, terminals, and transshipment points in the considered geographic area would have exceeded any reasonable level of involvement, the required details of each relevant terminal need to be collected individually as this information is not included in the publicly available data sources. On identifying the precise geo-locations of (potential) consignors, consignees, and transshipment terminals at a later stage in the AUTOFLEX project, information about the existing container handling equipment is to be collected in order to complement the existing data about each relevant terminal by the number of container cranes, reach stackers, or Ro-Ro ramps ready for service. Next, the respective demurrage fees per time unit, e. g., per day, and pierage (or port) fees per weight unit, e. g., per ton or per 100 tons, need to be retrieved for the relevant transshipment points. Another information to be collected is the container storage capacity at each relevant transshipment point. This additional effort becomes necessary as there is only sparse information publicly available about most of the transshipment points. Only larger inland ports tend to provide such information, e. g., about their respective storage capacity on site. For a qualified decision-making, however, such information needs to be replenished at a later stage.

As mentioned above, the focal interest in the AUTOFLEX project lies on cargo transshipment and vessel arrival and departure. For the latter, information about the berthing possibilities need to be collected. The following types of berths are included in the EuRIS portal (Rijkswaterstaat, 2020):

- a designated area on the waterway where a single vessel, convoy, sea plane etc. may anchor (anchorage berth)
- a berthing area at which transshipment of cargo is not permitted or possible (berth without transhipment)
- a berthing area at which transshipment of cargo is possible (and permitted) (transshipment berth)
- a berthing area at which embarkation and disembarkation of passengers onto a ferry boat or a passage vessel, respectively, is possible (ferry berth / passenger berth)

In the course of the AUTOFLEX project, berths with and without transshipment permission and/or facilities are the ones to focus on whereas anchorage berths, ferry berths, and passenger berths remain irrelevant for the research project. It has to be noted that some berths (with and without transshipment) are assigned to terminals while others are independent. Figure 4-16 shows the berths with and without transshipment facilities in the Use Case 1 and Use Case 2 areas.

Eventually, all terminals and berths carrying the same UN/LOCODE are subsumed under the name of the municipality linked to that code. This municipality is then considered a so-called port city when it exhibits at least one terminal in its geographic area (see Figure 4-17). Then, all terminals in that municipality and all berths related to those terminals make up the port city together, so that a coherent package of PoI information about each port city is provided. For geographic reasons, a centroid between the terminals is being calculated and the geo-location of the terminal with the shortest distance to that centroid is considered as a reference point. By this, travel planning and communication between consignors, consignees, vessel (or fleet) operators, and further stakeholders involved are simplified, e. g., for the estimation of arrival times and the provision of services on the subsequent transport legs.

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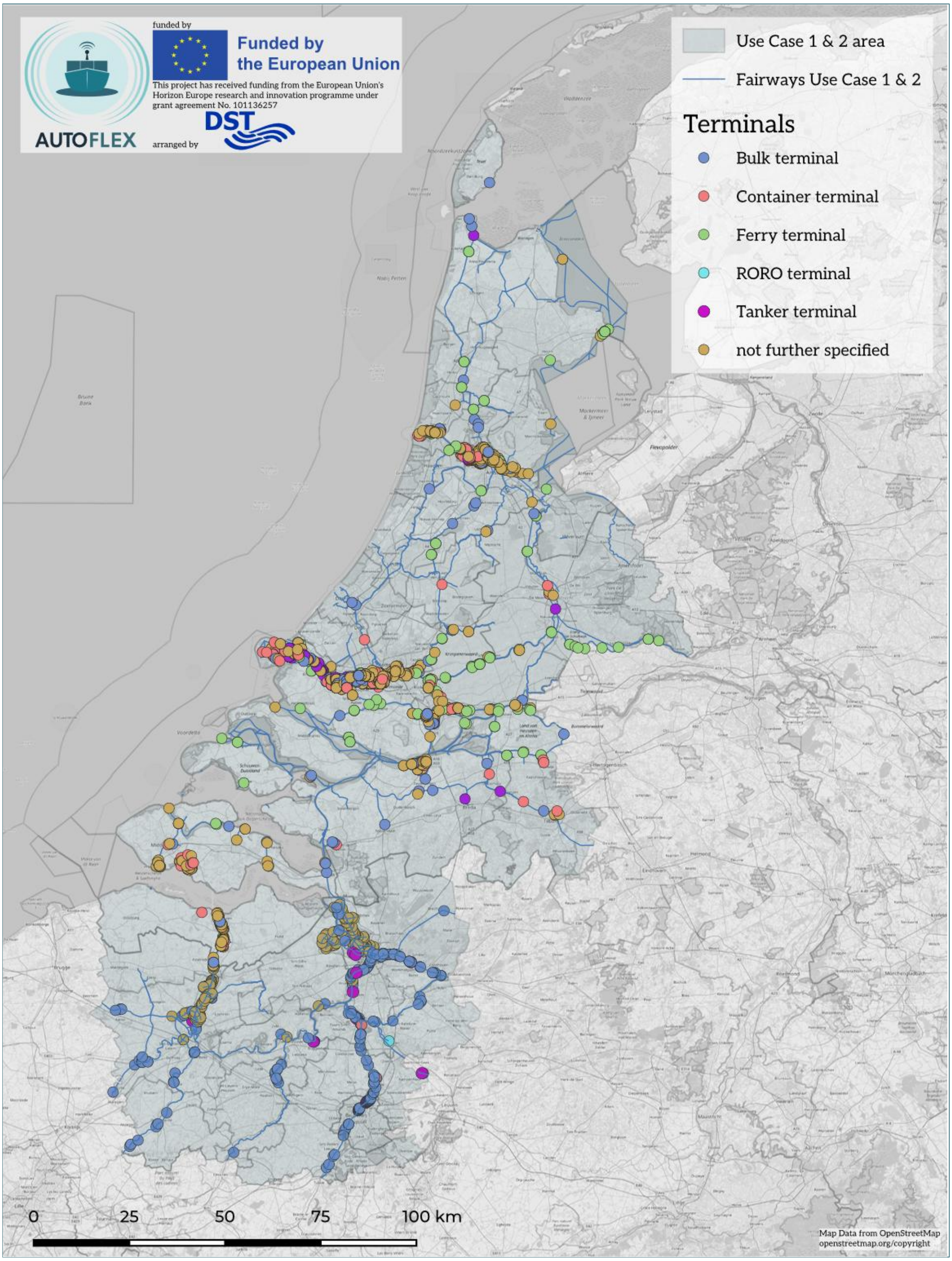

Figure 4-14: Terminal types in the Use Case 1 and Use Case 2 areas

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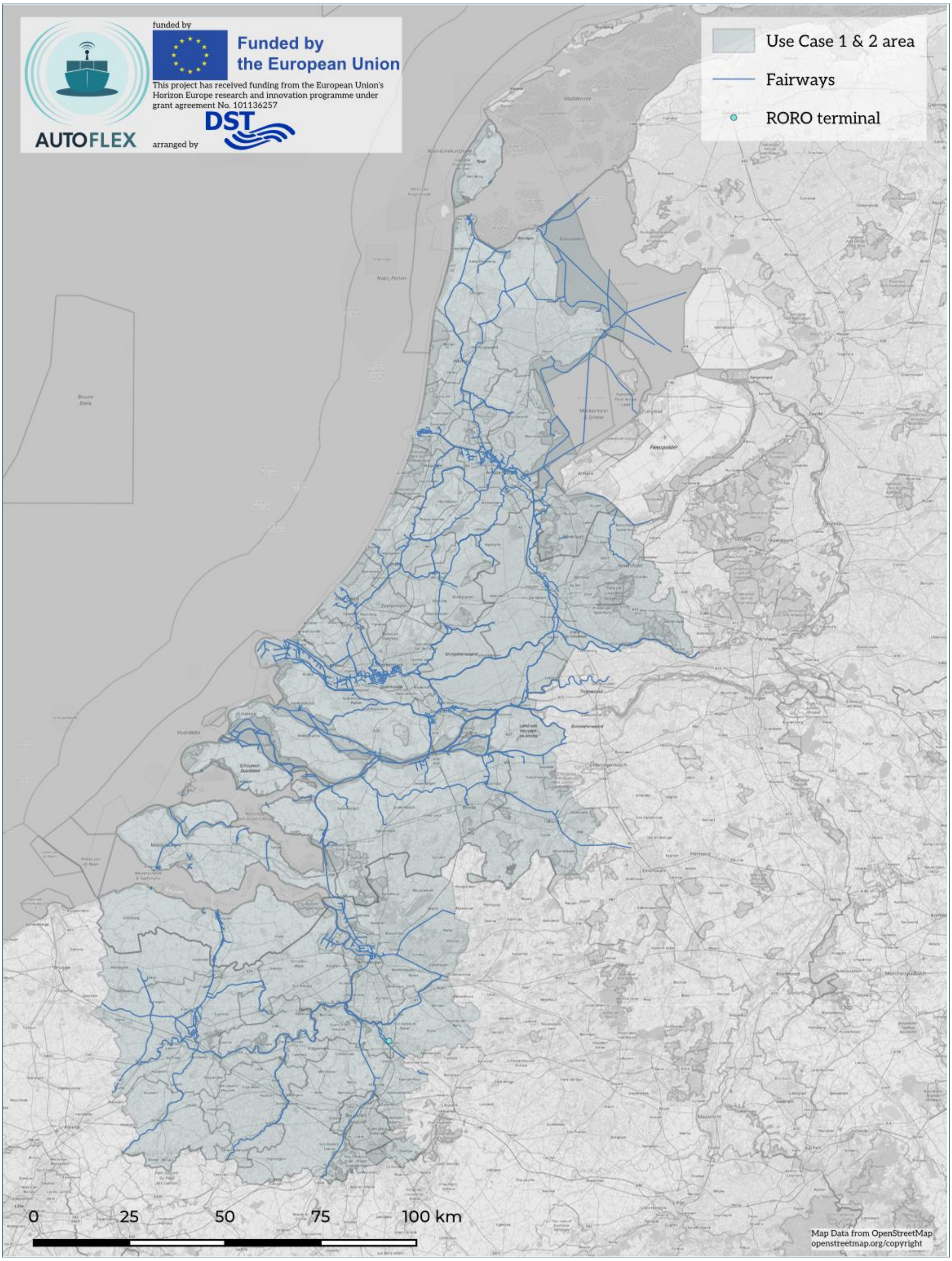

Figure 4-15: Ro-Ro terminals in the Use Case 1 and Use Case 2 areas

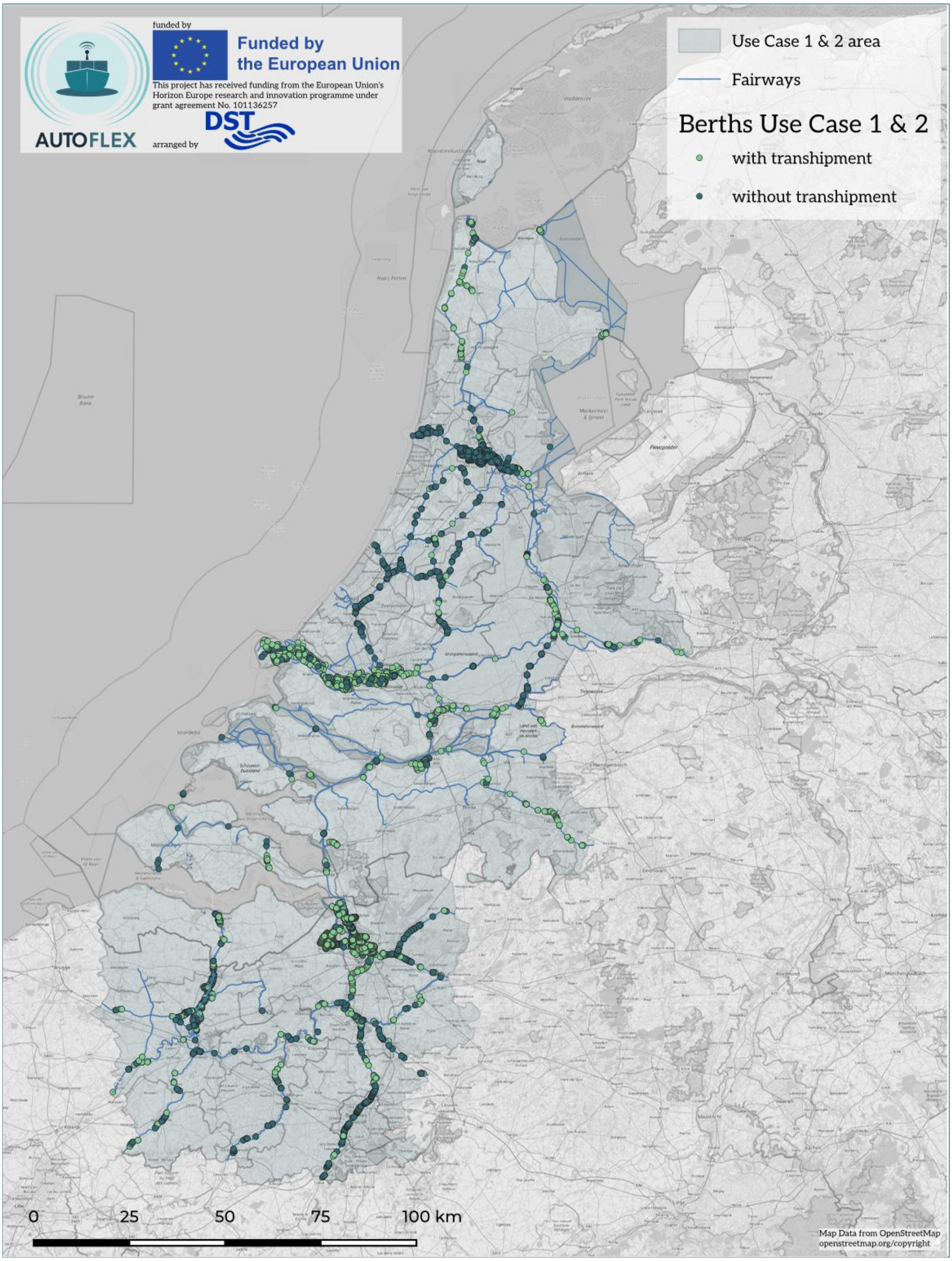

Figure 4-16: Berth types in the Use Case 1 and Use Case 2 areas

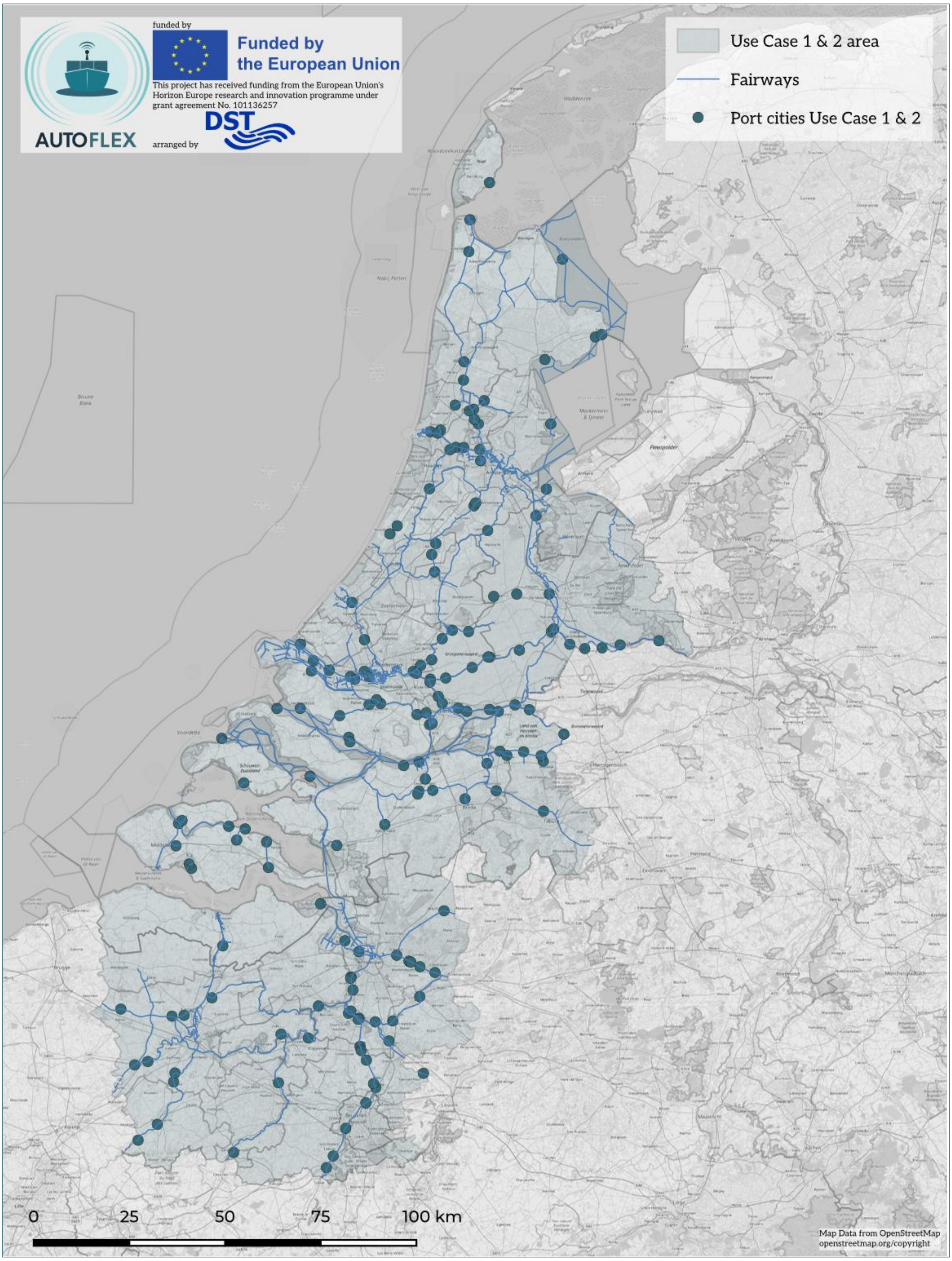

Figure 4-17: Port cities in the Use Case 1 and Use Case 2 areas

Figure 4-17 presents the port cities in the considered geographic areas of Use Case 1 and Use Case 2. It is striking but not surprising that a large part of the terminals are situated along the Rhine corridor, in the northern and western vicinity of Amsterdam, and between Antwerp and Brussels. The number of terminals within the Randstad region is noticeably low though which leaves room for the development and operation of temporary port terminals in case of economic need.

4.3 LOCKS AND WEIRS

A lock is a hydraulic structure that connects waterways with different water levels, permitting an inland vessel to sail from one level to another. Precisely, the inland vessel sails onto a wet dock or into a ship-lift in order to change from one inland waterway to another. Typically, the dimensions of the lock chambers and the opening times of the lock represent the most important data. The chamber dimensions confine the size of the inland vessels operating on that inland waterway stretch and are, thus, the most important data for IWT. The chamber length must exceed the vessel length by a few centimetres at least. The same applies to the width of the lock chamber which must be slightly bigger than the vessel beam.

Details of operation times of a lock have not been publicly accessible, at least not for all locks in the considered region. Therefore, the consortium members of the AUTOFLEX project need to make use of their existing datasets from previous research projects (in other geographic areas), scientific publications about the matter, or the experience of skippers operating in the considered region in order to derive the waiting times in front of the locks and actual lock operation times as well as to model the lock operation behaviour correctly and completely. These sources have been tapped, and the pertaining information has been collected.

Figure 4-18: Lock 'Nieuwe Sluis Terneuzen' in Terneuzen, the Netherlands[26]

[26] Image source: https://cadzand-online.de/wp-content/uploads/2016/06/terneuzen_nieuwe-sluis_2024_DJI_September-2024000017_0.jpg

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Apart from the dimensions, the opening times of a lock are of great significance for inland vessel operators. The related data is publicly available, e. g., from the national waterway authorities and the EuRIS portal. In addition, the lock fees as well as contact details to the control room are recorded there. Figure 4-18 shows the lock 'Nieuwe Sluis Terneuzen' on the Ghent-Terneuzen Canal, which has been inaugurated in October 2024 and is administered by the Flemish-Dutch Scheldt Commission.

Apart from locks, weirs also belong to the PoIs. A weir is a structure in a river to raise the water level or divert its flow. Unlike a dam that is supposed to impound water behind a wall, a weir is designed to alter the river flow characteristics. Hence, weirs represent hydraulic structures that resist the influence of the tide and, thereby, protect the area behind. Typically, weir structures can be lifted, lowered, or closed to impound the water flow and stop sailing on the waterway. Figure 4-19 shows the iconic 'Stuw- en sluizencomplex Hagestein', a combined lock and weir in Hagestein, the Netherlands.

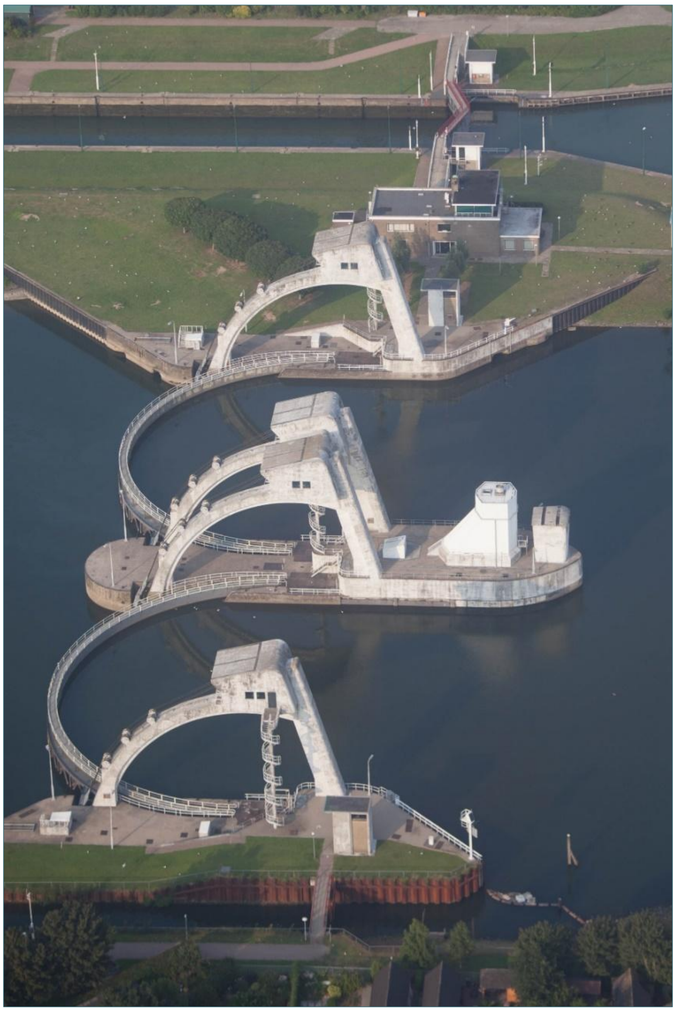

Figure 4-19: Combined lock and weir 'Stuw- en sluizencomplex Hagestein' in Hagestein, the Netherlands[27]

[27] Image source: https://upload.wikimedia.org/wikipedia/commons/d/d0/Hydro_power_in_the_River_Rhine_in_Holland_%289659091328%29.jpg

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4.4 BRIDGES AND OVERHEAD STRUCTURES

Bridges are relevant for the network in terms of clearance height of an inland vessel as the height restricts the number of container layers allowed. Typically, two height readings are of relevance, the bridge height under normal conditions and the bridge height at flood. It has to be noted though that this statement is true for fixed bridge structures only as movable bridges might have two different heights per condition (i.e., when opened or closed).

In the publicly accessible dataset of the EuRIS database, a distinction is made between a bridge, a bridge area, and a bridge opening (Rijkswaterstaat, 2020, pp. 29–31):

- bridge: a bridge construction (in the real world) spanning and providing passage over a barrier or gap, such as a river or roadway, typically differentiated by type of operation.
- bridge area: the encoding (of a bridge) in the RIS Index, representing a bridge construction in the real world.
- bridge opening: the individual passage opening of a bridge construction, featuring an individual clearance height and representing one potential lane on the fairway.

In the RIS Index, a bridge construction, colloquially referred to as a 'bridge', is represented as a 'bridge area' and assigned all individual bridge openings of that particular bridge construction. As bridges may typically be separated by no, one, or several pillars in the inland waterway, the number of bridge openings may amount to one or any number higher than one (per bridge construction). Accordingly, one or several potential lanes may be accessible for the inland vessel sailing on the respective inland waterway and passing the respective bridge construction. For each bridge in the real world, the ISRS code of the bridge area summarises the entire bridge construction, regardless of the precise number of bridge openings. Further, each bridge opening features a geo-location[28] and the clearance height(s) (for the different conditions mentioned above) as well as a unique ISRS code which links it to the pertaining bridge area. The ISRS codes of the bridge areas feature information about the number of the bridge on a particular waterway stretch (as several bridges may occur on one stretch) and the number of the respective bridge opening of that particular bridge. Thereby, a bridge area consists of one or several bridge openings. However, the clearance heights are determined per bridge opening whereas the entry of a bridge area does not contain any such information as the clearance information is not linked with the entry 'bridge area'. Hence, a detailed analysis needs to be conducted in order to identify bridge constructions, collect the respective clearance heights of its one or several bridge openings, and use the different clearance heights as reference values for checking the passability of an inland vessel with a particular height. For certain, determined cases, this will be possible with manageable effort whereas the same exercise for the bridges in the entire Use Case 1 and Use Case 2 areas would have required significantly higher effort.

For a safe passage of bridges (and the precise bridge openings), the clearance heights need to be respected. In order to determine the permitted number of container layers on a particular vessel or vessel type, the maximum possible load draft and the vertical clearance under bridges form the two boundaries for the related calculation. Figure 4-20 illustrates different load scenarios for a class IV container inland vessel and shows the empty case as well as the fully loaded case and presents both the draft (below 0) and the maximum

[28] At times, different bridge openings of the same bridge construction exhibit the same geo-location in the EuRIS dataset.

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permissible clearance height (above 0) in the cases of two, three, and four container layers. While the blue bars represent the case of vessels without ballasting, the purple ones refer to the case with ballasted vessels.

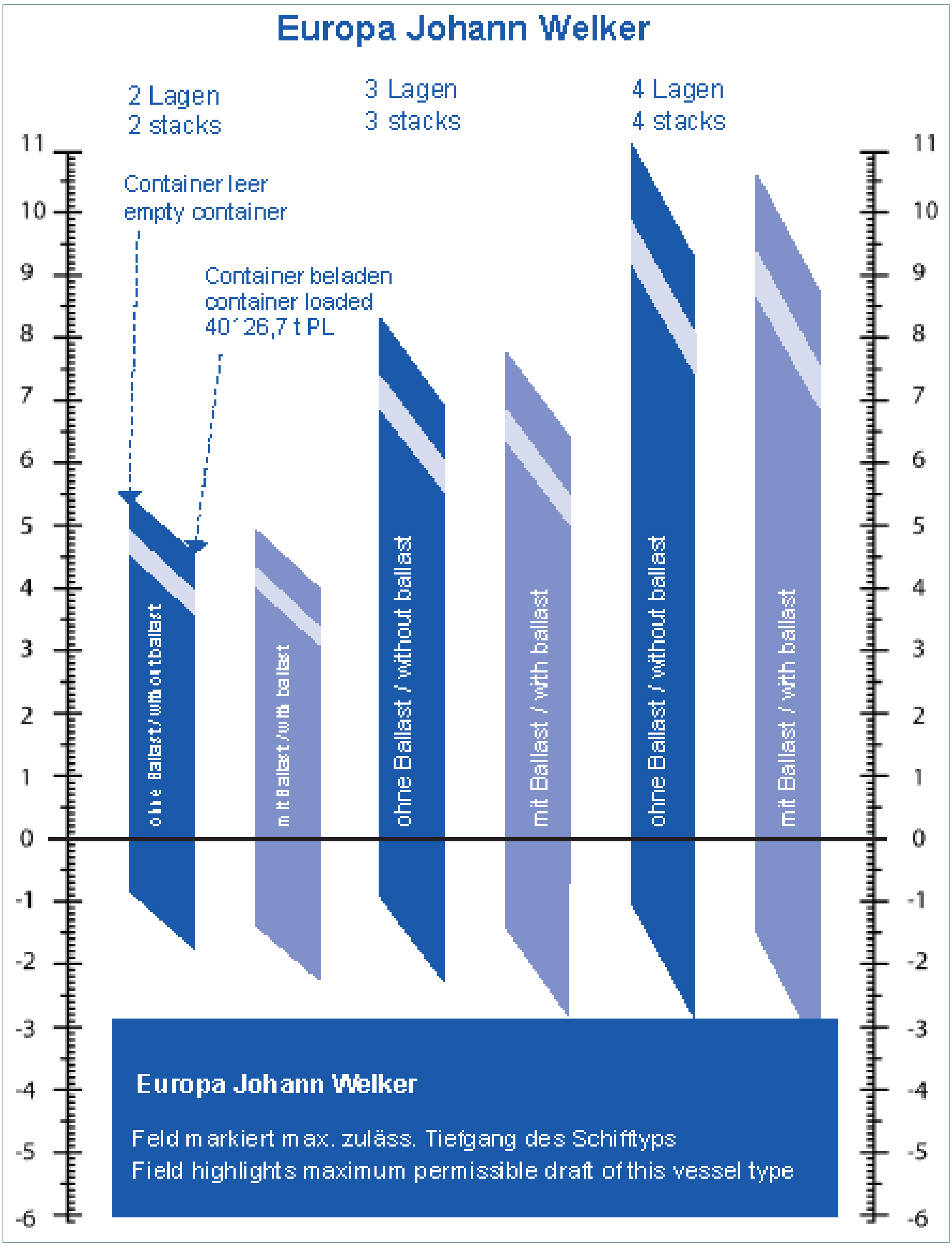

Figure 4-20: Clearance heights of a class IV container inland vessel[29]

[29] image source: DST / Bieker (retrieved from VBW (2012, p. 50))

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Apart from the height, the bridge type is recorded as the heterogeneity of bridges is evident. Bridges can be distinguished in fixed and movable structures. The fixed ones can only be passed by inland vessels by sailing through underneath the structure whereas movable ones have the possibility to transform their structure in such a way that the fairway is freed and the inland vessel can pass. In operational terms, this means that the above-mentioned bridge clearance height is relevant to the passage of fixed bridges only whereas the passage of movable ones is not restricted by its height although technically lift bridges do exhibit a second clearance height when opened. This height, however, is considerably above the required clearance height for a typical number of container layers in IWT.

Moreover, overhead structures need to be considered as well as they appear crossing and overarching inland waterways. Hence, they need to be treated like fixed bridge structures.

According to the RIS Index Encoding Guide, the following bridge types and overhead structures are typically discriminated against (Rijkswaterstaat, 2020, pp. 29–34):

- Bascule bridge: a counterweight bridge that is rotated in a vertical plane about an axis at one or both ends
- Drawbridge: a movable bridge, which is sometimes called a thrust bridge, where the deck can be rolled and slid backwards (or pushed to one side, respectively) to open a gap for crossing traffic (e. g., from inland vessels)
- Fixed bridge: a bridge with a permanent horizontal and vertical structure
- Lift bridge: a movable bridge (or a span of it) capable of being lifted vertically to facilitate the passage of inland vessels beneath
- Suspension bridge: A fixed bridge consisting of either a roadway or a truss suspended from two or more cables running over towers and anchored by backstays to a fixed foundation
- Swing bridge: a movable bridge (or a span of it) rotating in a horizontal plane about a vertical pivot point to facilitate the passage of inland vessels
- Bridge with bridge arches: a bridge, oftentimes a fixed one, with bridge arches rather than straight construction
- Overhead cable: an arrangement of wires, fibres, a wire rope or a wire chain supported by structures crossing and overarching an inland waterway
- Overhead pipe: a pipeline supported by pylons crossing and overarching an inland waterway

While the fixed bridge and the suspension bridge belong to the category of fixed bridge structures, the residual types are categorised as movable bridge structures. The overhead structures are also assigned to the earlier category so that the passing vessels need to respect the clearance height.

Picture of a fixed bridge (see Figure 4-23), a bascule bridge (see Figure 4-21) and a drawbridge (see Figure 4-22), all situated in the Use Case 2 area., are shown in the following. Also, Figure 4-26 presents an image of a swing bridge while Figure 4-27 shows a suspension bridge in Belgium (Use Case 2 area). Moreover, two bridges from Rotterdam (Use Case 1 area) are presented in Figure 4-25 (vertical lift bridge) and Figure 4-24 (fixed bridge with two bridge arches).

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Figure 4-21: Bascule bridge 'Victor Dumonbrug' in Willebroek, Belgium[30]

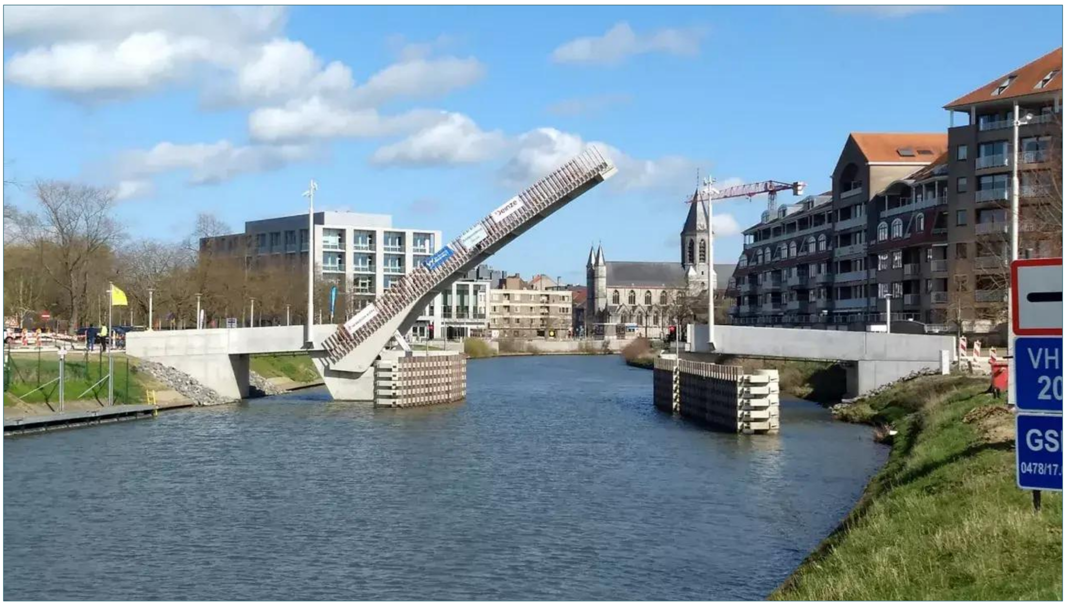

Figure 4-22: Drawbridge 'Brielpoortbrug' in Deinze, Belgium[31,32]

[30] Image source: https://www.wikidata.org/wiki/Q2179537#/media/File:Victor_Dumonbrug.jpg
[31] Image source: https://images.vrt.be/width1280/2021/03/26/f94968c8-8e1f-11eb-b07d-02b7b76bf47f.jpg
[32] Further information about the Brielpoortbrug bridge can be found here: https://www.vrt.be/vrtnws/nl/2021/03/26/brielpoortbrug-in-deinze-klaar/

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Figure 4-23: Fixed bridge ‘Spoorbrug’ in Duffel, Belgium[33]

Figure 4-24: Fixed bridge ‘Van Brienenoordbrug’ in Rotterdam, the Netherlands[34]

33 Image source: https://commons.wikimedia.org/wiki/File:Duffel_Spoorbrug_6.jpg

34 Image source: https://megaconstrucciones.net/scripts/timthumb.php?src=/images/puentes/foto3/van-brienenoordbrug.jpg

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Figure 4-25: Vertical lift bridge ‘Botlekbrug’ in Rotterdam, the Netherlands[35,36]

Figure 4-26: Swing bridge ‘Predikherenbrug’ in Ghent, Belgium[37,38]

35 Image source: https://www.spie-nl.com/sites/default/files/styles/header_image/public/2021-11/Botlekbrug.jpg.webp

36 Further information about the Botlekbrug bridge can be found here: https://www.rijkswaterstaat.nl/wegen/projectenoverzicht/a15-botlekbrug-nieuwe-verbinding-weg-en-goederenspoorverkeer-scheepvaart-en-bromfietsers/doelen-en-resultaten

37 Image source: https://img.nieuwsblad.be/lqpEffgGOEEunI6xLYAtaQFPC-w=/1280x853/smart/https%3A%2F%2Fstatic.nieuwsblad.be%2FAssets%2FImages_Upload%2F2013%2F05%2F31%2Fbrug5.jpg

38 Further information about the Predikherenbrug bridge can be found here: https://www.nieuwsblad.be/cnt/blmva_20130531_001

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Figure 4-27: Suspension bridge 'Ledeberg Leeft' in Ghent, Belgium[39]

After having considered various bridge types and the concept of the clearance height, the next aspect to consider are bridge openings. Depending on the structural design of the bridge construction, the number of bridge openings due to pillars (or other structures) in the waterway may vary between one and six in the Use Case 1 area and between one and five in the Use Case 2 area, respectively. A bridge with exactly one opening spans the inland waterway from shore to shore whereas a bridge construction with several openings require a number of pillars in the inland waterway, which may cut it into different lanes.

It has to be noted that one bridge construction on the map may consist of several bridge elements (and bridge openings) combined to a coherent structure. In such a case, the bridge appears like a singular bridge with multiple pillars in the waterway, leading to potentially multiple lanes allowing passage of the bridge through different bridge openings and different clearance heights valid on the various lanes due to the respective bridge type. On the map, each individual bridge opening is represented so that a bridge construction may be represented by a series of icons – each one for a different bridge element (and bridge opening). With respect to travel planning, it can be assumed that a movable bridge structure may be used for passage whenever available – and required due to an insufficient clearance height on other lanes.

Figure 4-28 shows the Stadsbrug Zwijndrecht, a bridge complex which connects the cities of Zwijndrecht and Dordrecht in the Netherlands and which consists of a road and a rail bridge. Technically, it is a bridge construction with a bascule bridge (on a part of the road bridge) and a lift bridge (on a part of the rail bridge) while the residual parts of both bridges remain fixed (as can be seen in Figure 4-29). Inland vessels can pass the bridge construction either through the bridge openings of the fixed bridge while respecting the clearance heights or through the opening of the lift and bascule bridges on whose lane the clearance height is

[39] Image source: https://lh3.googleusercontent.com/yE0aZgbhFVD8qjWktFdJ--w0fwb0t069uFZr7UHuxOiPX4yDW2nI0UTW8PzdU4kB2lPZH6Zqf0fPpKBtZFshWm4=l80-w450-e365

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unlimited. In the case of Stadsbrug Zwijndrecht, both the bascule bridge and the lift bridge are opened for a passing inland vessel (see Figure 4-30).

In the map, the representation of the bridges differs due to the underlying EuRIS data. Naturally, the zoom level of the map has a strong impact on the visibility as the lowest zoom factor leads to a very high view level with a vast area covered and displayed but with less detail. On the contrary, the highest zoom level may show each point of interest, particularly each bridge opening individually, but in a spatially confined area only. Figure 4-32 and Figure 4-33 show two bridge constructions, one in each of the two considered use case area: The bridge construction “Stadsbrug Zwijndrecht” consists of multiple bridge openings, some of which movable and the others fixed. In the left half of the map shown in Figure 4-32, the bridge appears as one entry, i. e., one bridge opening, whereas the right half of the map reveals the actual number of bridge openings. The bridge construction “Lillobrug”, a combined road and railway bridge situated in the port of Antwerp, consists of several bridge openings, as can be seen in .Figure 4-31. The pertaining map representation shown in Figure 4-33, however, displays a different picture: Only one representation for the different fixed bridge openings and another one for the movable bridge elements is shown on the right half of the map displayed in Figure 4-33 (while the left half shows one representation of a bridge opening only).

Figure 4-28: Bridge complex ‘Stadsbrug Zwijndrecht’ in Zwijndrecht, the Netherlands[40]

[40] Image source: https://www.wegenwiki.nl/images/Stadsbrug_Zwijndrecht.jpg

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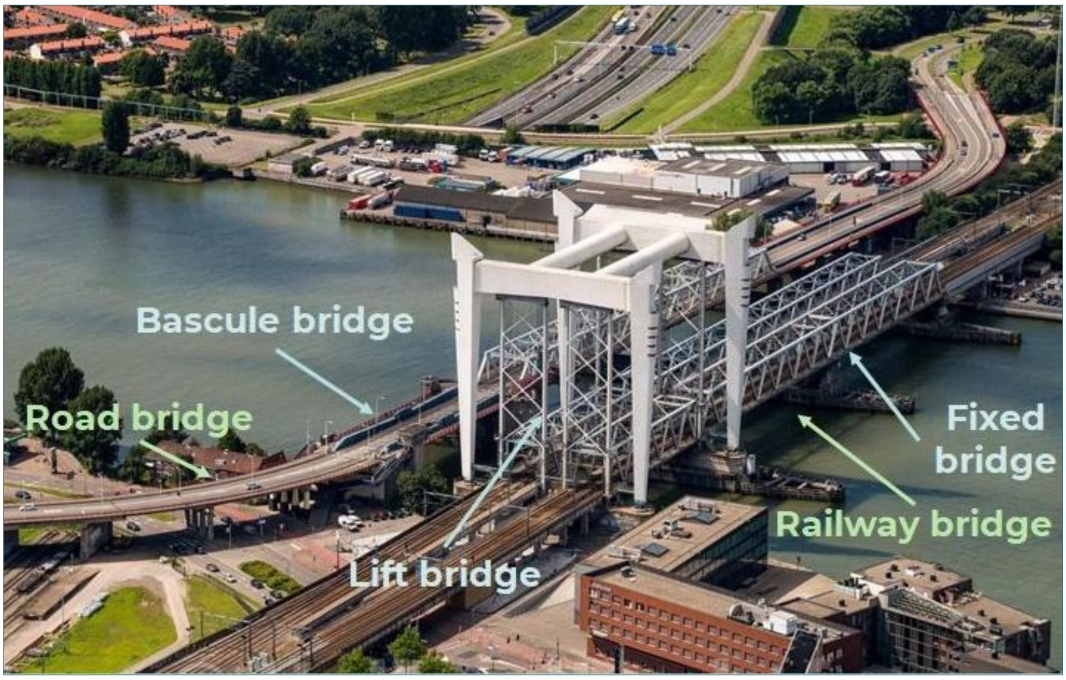

Figure 4-29: Composition of bridge elements of the bridge complex 'Stadsbrug Zwijndrecht'[41]

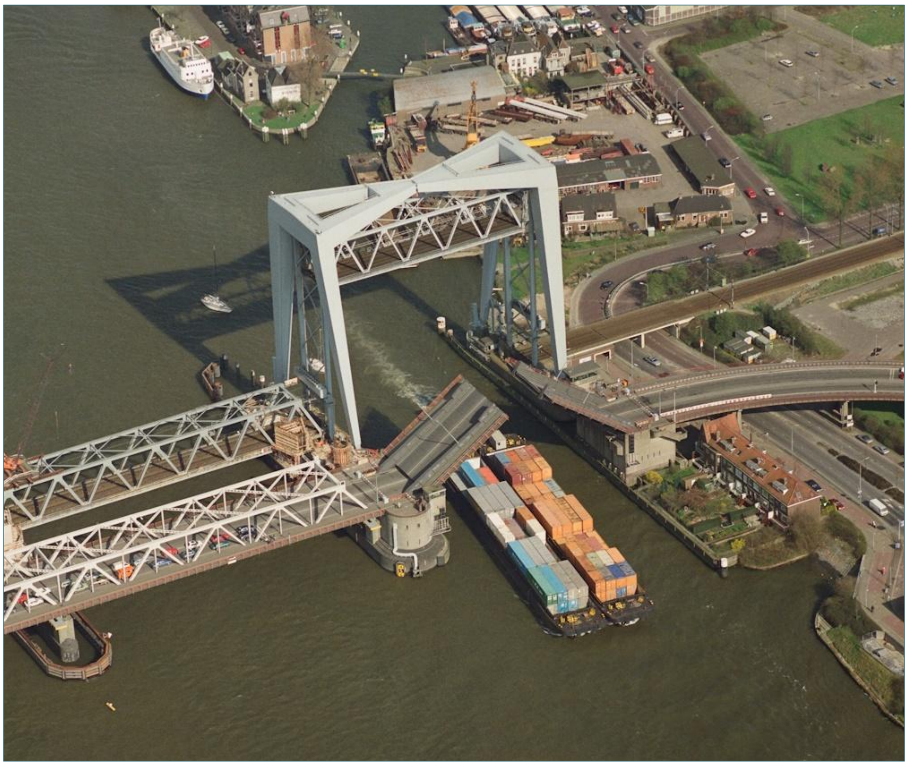

Figure 4-30: Vessel passage through the bridge complex 'Stadsbrug Zwijndrecht'[42]

[41] Image source: https://d3e1m60ptf1oym.cloudfront.net/19a5029e-7256-4904-9aa5-a9dc4be69213/Luchtfoto_Dordrecht_spoor-_en_autobrug_over_de_oude_Maas-1_xgaplus.jpg
[42] Image source: https://www.wegenwiki.nl/images/Verkeersbrug_Dordrecht_1989.jpg

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Figure 4-31: Bridge complex ‘Lillobrug’ in Antwerp, Belgium[43]

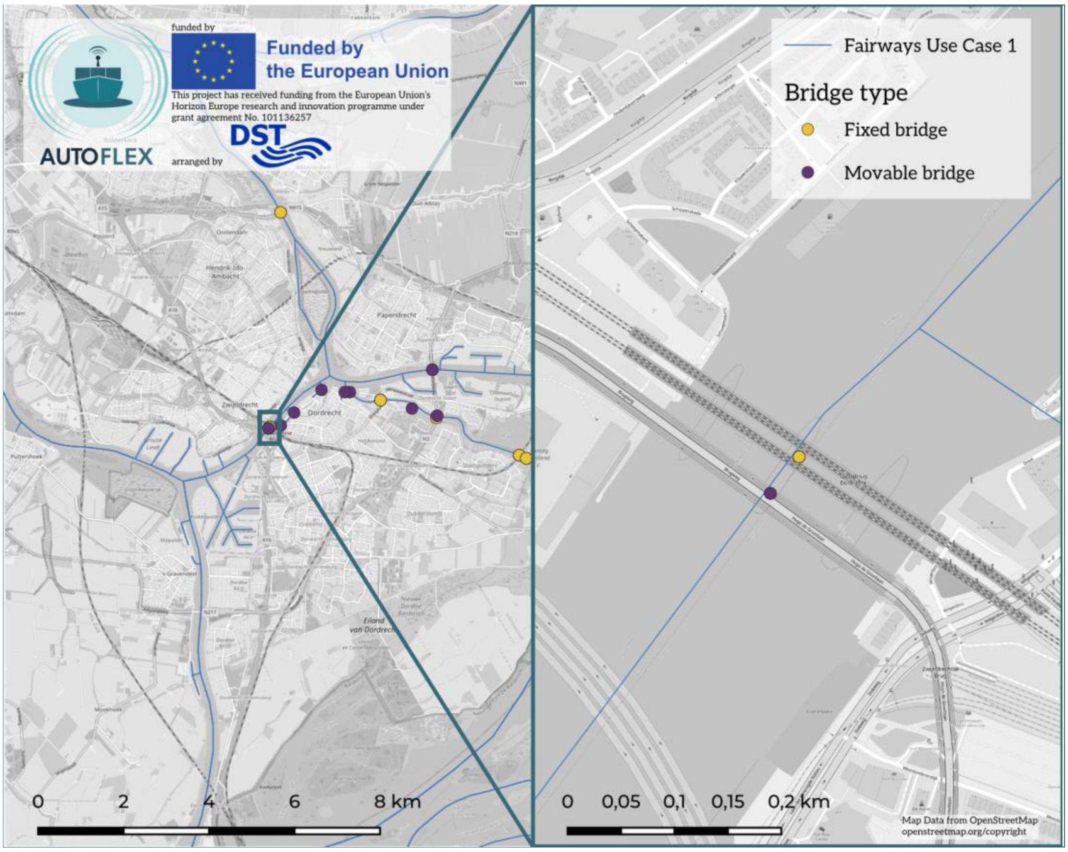

Figure 4-32: Example of the map representation of the Stadsbrug Zwijndrecht in the Use Case 1 area

43 Image source: https://upload.wikimedia.org/wikipedia/commons/5/53/Lillobrug_open_%28looking_East%29.jpg

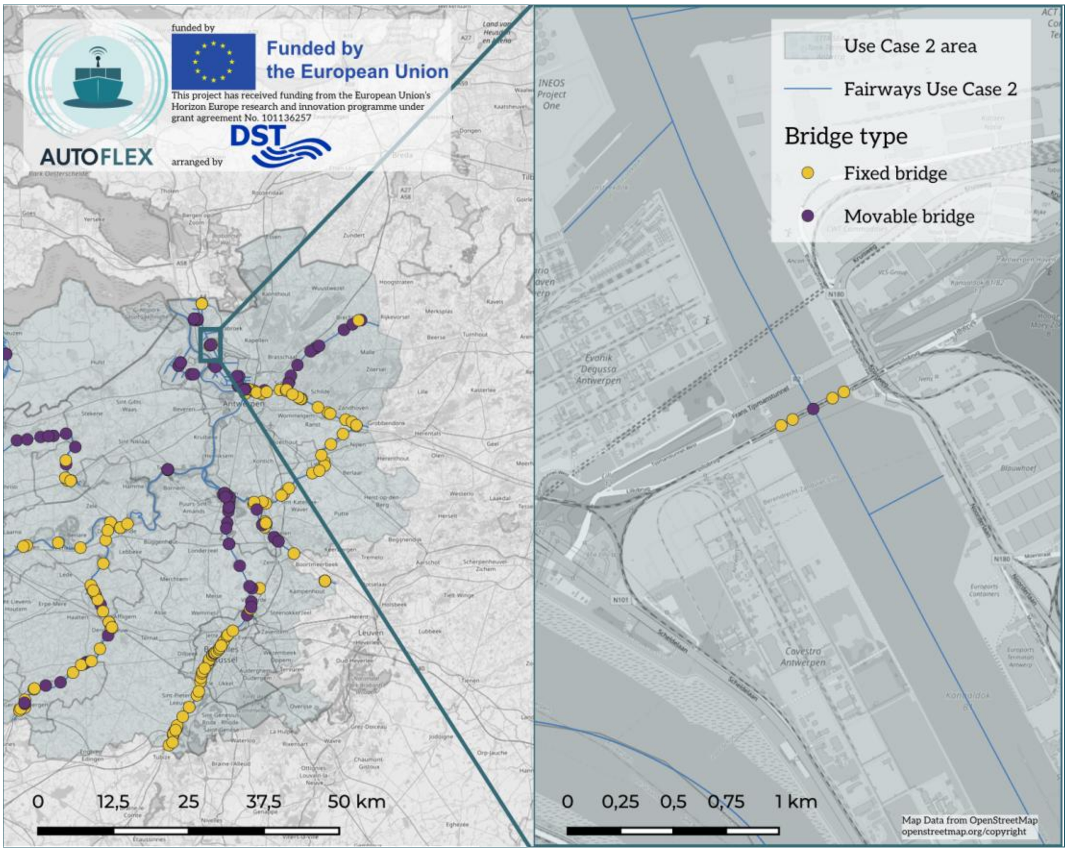

Figure 4-33: Example of the map representation of the Lillobrug (in the port Antwerp) in the Use Case 2 area

The number of bridge openings in the two use case areas amounts to a total of 2,367 bridge openings (and bridge elements) of eight different bridge types. In the Use Case 1 area, 476 bascule bridges, 113 drawbridges, 41 lift bridges, and 79 swing bridges sum up to 709 movable bridges whereas 1,143 fixed bridges, three overhead pipelines, and 99 overhead cables result in 1,245 fixed structures in the same geographic area. For the Use Case 2 area, a total of 114 movable bridges consist of 20 swing bridges, 17 lift bridges, 23 drawbridges, and 54 bascule bridges while 294 fixed bridges, 2 suspension bridges, and 3 overhead pipelines add up to 299 fixed structures altogether. Figure 4-34 shows all bridge elements in the Use Case 1 and Use Case 2 areas. The differentiation between fixed and movable bridges is illustrated in the subsequent map in Figure 4-35. Both maps show all individual bridge elements, regardless of their affiliation to a bridge construction. The maps do not show the individual bridge constructions. As described above, this is related to the structure of the underlying EuRIS data. Hence, it is advisable to take a closer look at the location in question in a specific case and, thereby, uncover the various bridge elements at one location.

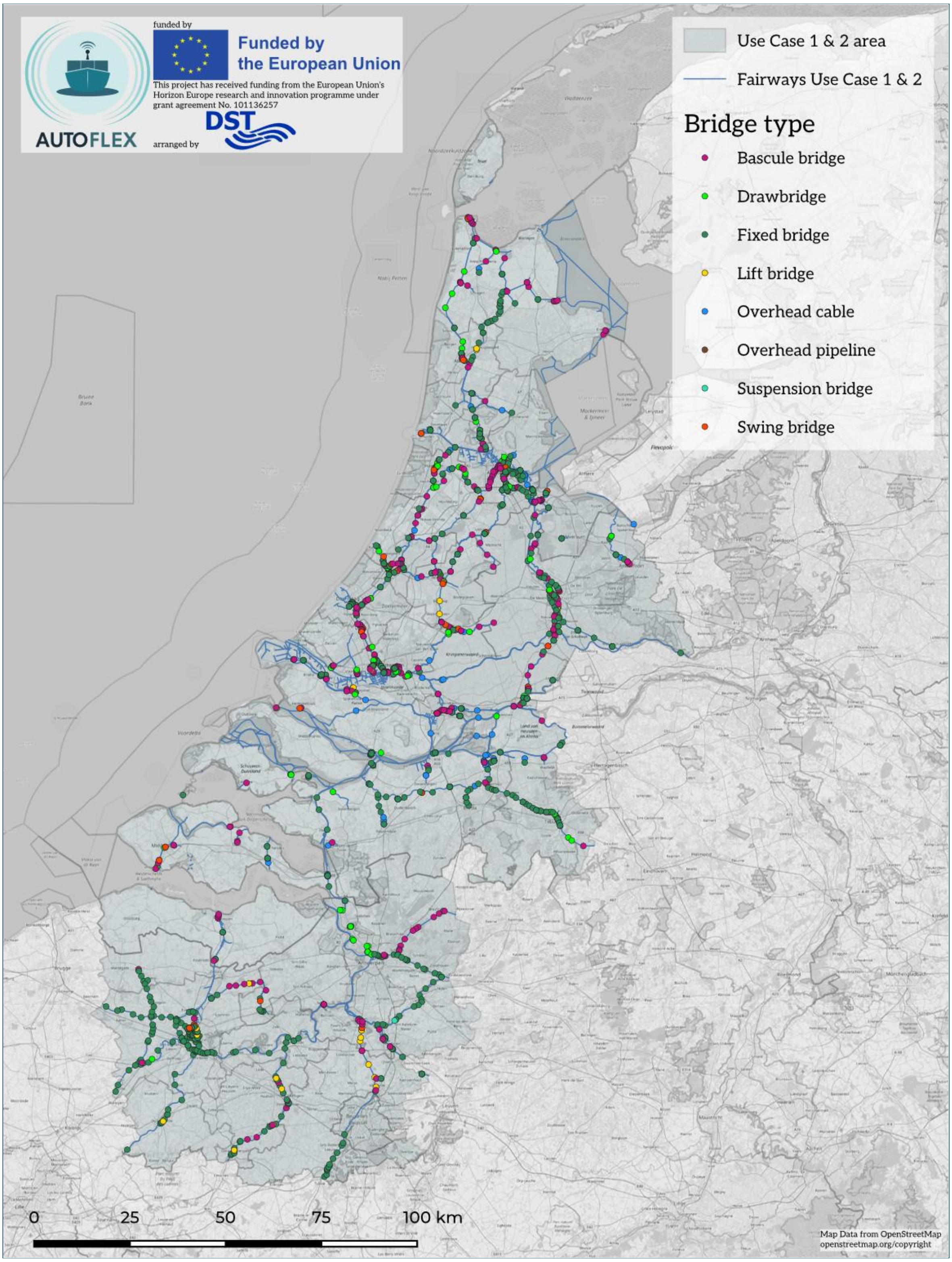

Figure 4-34: Types of bridge openings over inland waterways in the Use Case 1 and Use Case 2 areas[44,45]

[44] excl. class 0 and uncategorised inland waterways
[45] Display per bridge opening

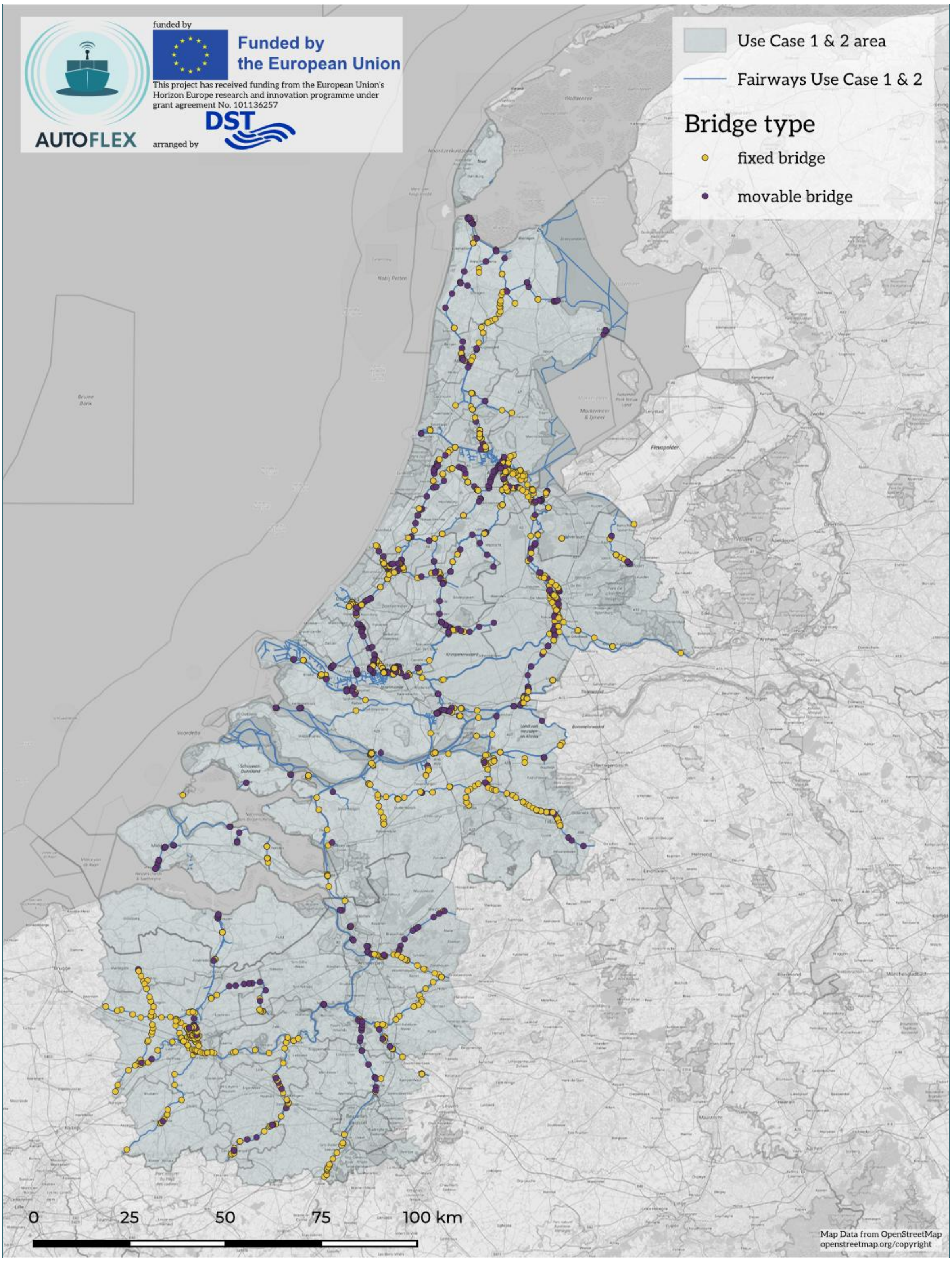

Figure 4-35: Fixed and movable bridge openings over the inland waterways in the Use Case 1 and Use Case 2 areas[46]

[46] Display per bridge opening

4.5 GAUGES

A (stream) gauge is a location, predominantly used by hydrologists or environmental scientists, to monitor terrestrial water bodies like rivers. Hydrometric measurements of water level surface elevation and volumetric discharge (i. e., flow) are generally taken. Observations of water quality and biota may also be made. Gauges are of significance to inland waterway container transport operation as their water levels are taken into account for a fair pricing and compensation of inland vessel operators for the effects of extreme low-water events. The lower drafts lead to impeded navigability, less vessels able to navigate to destinations beyond critical spots, lower utilisation of the vessel, lower speeds, longer lead times, and higher energy consumption. Further, the extreme low-water events lead to a volatile transport market with temporarily exacerbating prices for transport services, shortage of small vessel capacity on very short notice, and a gradual shift from IWT to road and rail transport – which leads to a further aggravation of the market situation there (due to scarce capacity and congested and overloaded infrastructure) (Kempmann et al., 2023).

Figure 4-36 shows the geo-location of the gauging stations in Belgium and the Netherlands. It is immediately striking that the Netherlands has a plethora of gauging stations whereas Belgium hardly exhibits one. Hence, it must be questioned whether the data of the Belgian inland waterway network is complete, consistent, and correct in this respect or whether all existing gauging stations have been listed in the portal. On the other hand, a glance at the tide-dependency of the waterways may indicate a potential explanation for the geographic dispersion. The Use Case 1 area features 71 gauges (see Figure A-1 in the Appendix). They are located on the outer ring around the Randstad region and in the southwestern part of the area. The Use Case 2 area features nine gauges, all of which are located along the Dutch part of the Terneuzen-Ghent Canal. Figure A-2 in the Appendix shows a map of the locations of the gauges.

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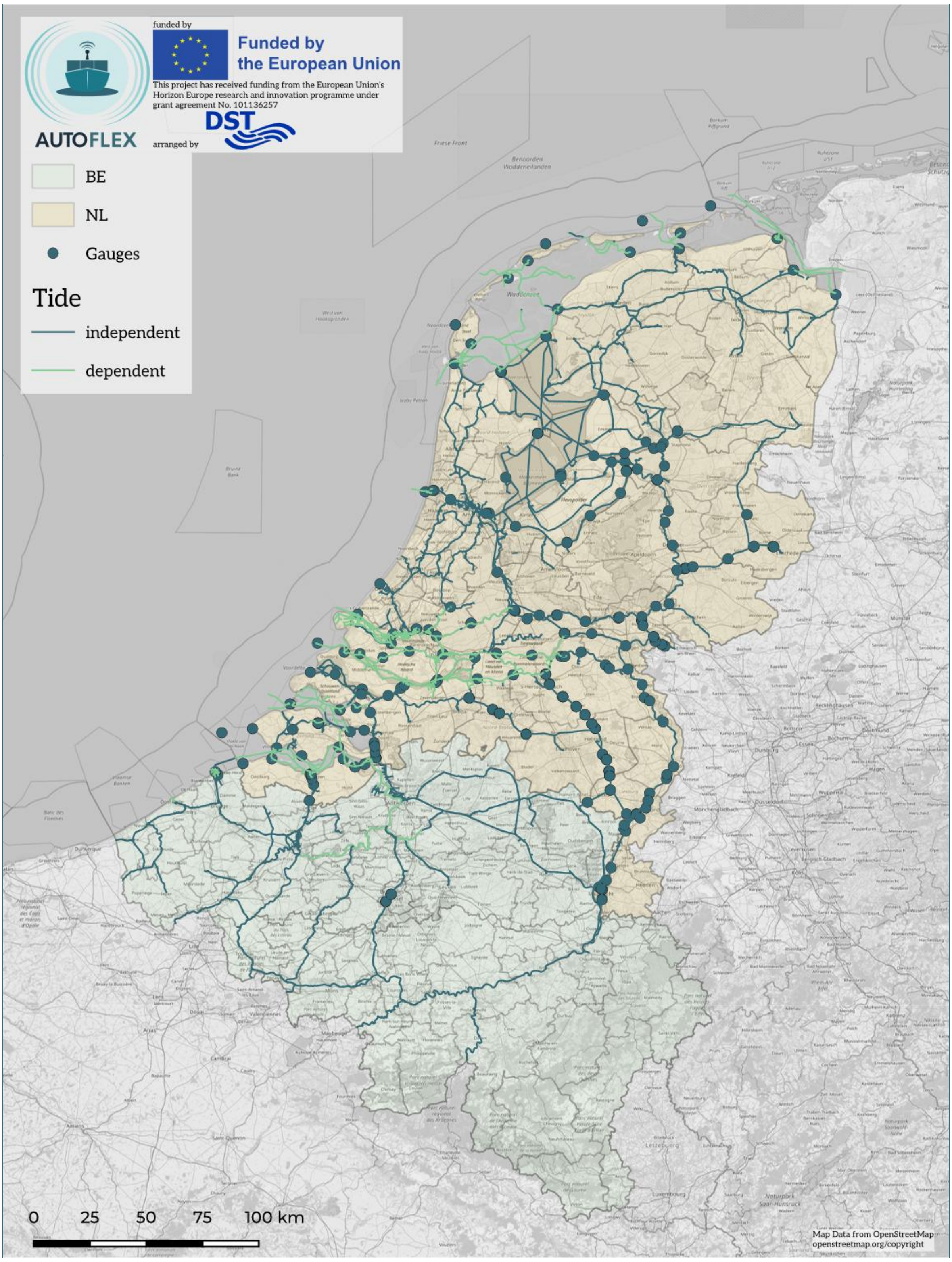

Figure 4-36: Gauges and tide-dependency of the inland waterways in the Use Case 1 and Use Case 2 areas

5 INITIAL IMPLICATIONS FOR THE DESIGN OF INLAND VESSELS AND TRANSPORT SYSTEMS

Based on the inland vessels designed in the fourth work package (WP 4) of the AUTOFLEX project, named "Developing small automated zero-emission vessels", Table 5-1 shows the dimensions and cargo-related parameters of the AUTOFLEX inland vessels. The CEMT class II and CEMT class IV inland vessels are used as reference vessels for the nautical and vessel operational considerations (Bačkalov et al., 2024).

Particularly, the bridge clearance is considered for both reference vessel types in each of the two use cases. As can be seen in Figure 5-1, a double-layer container transport with the AUTOFLEX CEMT class II inland vessel leads to a clearance height of 4.08 metres (i. e., 5.78 metres vessel height plus 30 centimetres for safety distance, reduced by a draft of two metres). The same case with an AUTOFLEX CEMT class IV inland vessel considers 6.17 meters (i. e., 8.73 metres plus 30 centimetres as safety distance, reduced by a draft of 2.50 metres) as the clearance height (see Figure 5-2). Table 5-2 presents the vessel heights of the AUTOFLEX inland vessels used as references as well as the clearance heights in the case of single- and multi-layer container transport.

It should also be noted that the different vessel types have different clearance heights despite the same number of loaded container layers, as each of them rises out of the water to different heights. For instance, one container layer on the AUTOFLEX CEMT class II inland vessel leads to a clearance height of 2.19 meters while the same container layer on the AUTOFLEX CEMT class IV inland vessel results in a clearance height of 1.69 meters. This is mainly rooted in the draft of the inland vessels as the AUTOFLEX CEMT class II inland vessel features a draft of two metres whereas the AUTOFLEX CEMT class IV inland vessel exhibits two and a half metres of draft. Moreover, the additional installation on top of the vessel is assumed with a safety interval (of assumed 70 centimetres) as the technical details need to be determined in the course of the AUTOFLEX project. The constructions become relevant in the case of single-layer container transport. Further, the safety of each bridge passage is ensured with a safety distance of 30 centimetres in addition to the actual clearance height.

Table 5-1: Overview of AUTOFLEX vessel types

AUTOFLEX vessel type	**CEMT class**	**Length L** [m]	**Width B** [m]	**Draft d** [m]	n_{TEU}	n_{Tiers}	m_{Cargo} [t]
"Theodor Bayer" (2024)	I	38.50	3.74	1.50	4 or 8	1 or 2	69
"Oskar Teubert" (2024)	II	53.00	6.30	2.00	24	2	400
"Gustav Koenigs" (2024)	III	67.00	6.30	2.00	28	2	463
"Johann Welker" (2024)	IV	85.00	9.50	2.50	86	3	1,279

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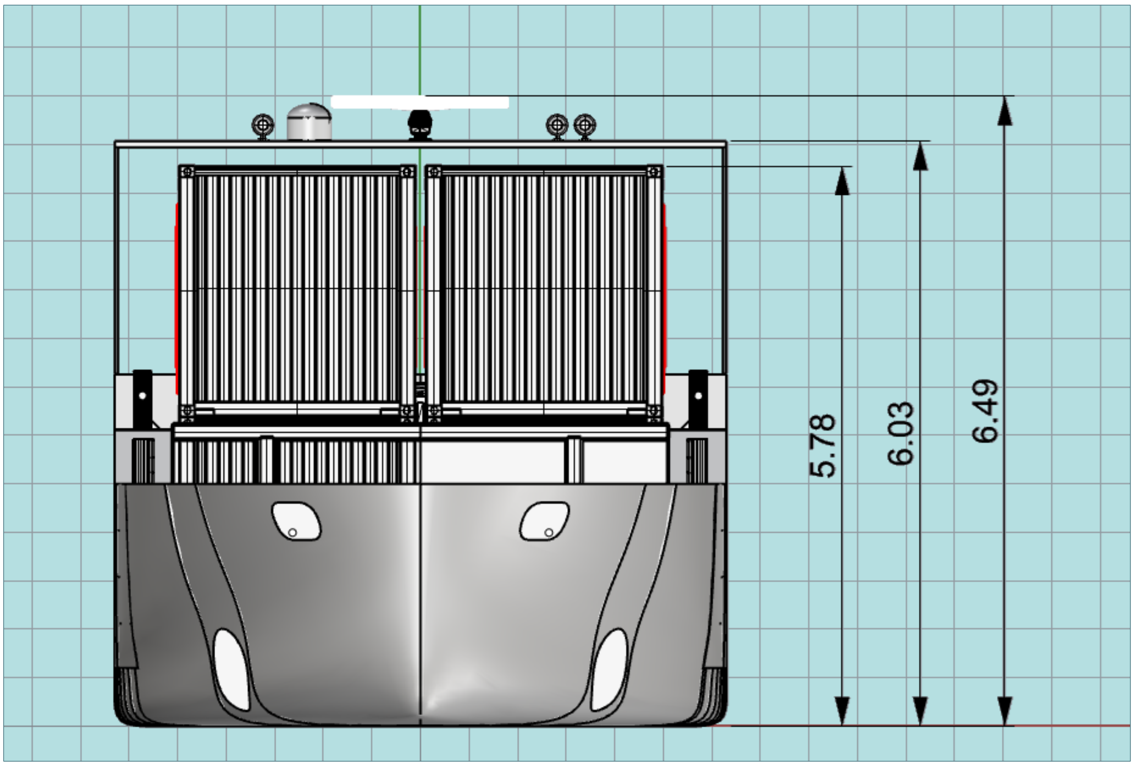

Figure 5-1: Vessel height of CEMT class II inland vessel of the AUTOFLEX project

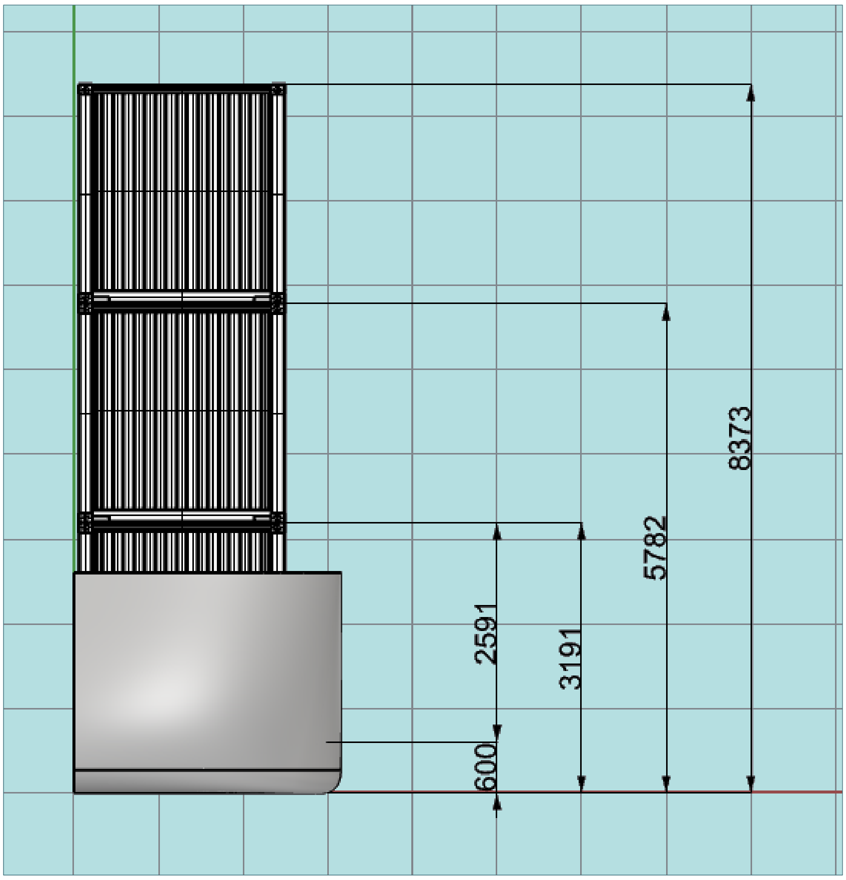

Figure 5-2: Vessel height of CEMT class IV inland vessel of the AUTOFLEX project

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Table 5-2: Vessel height and clearance height of the AUTOFLEX inland vessels

Vessel type, loading case	**Construction** (bottom)	**Height** of **1st cont. layer**	**Height** of **2nd cont. layer**	**Height** of **3rd cont. layer**	**Construction** (top; with 1st layer)	**Vessel height**	**Draft**[47]	**Safety distance** (for bridge passage)	**Clearance height**
CEMT class II, 0 cont. layer	3.89					**3.89**	2.00	0.30	**2.19**
CEMT class II, 1 cont. layer	0.60	2.59			0.70	**3.89**	2.00	0.30	**2.19**
CEMT class II, 2 cont. layers	0.60	2.59	2.59			**5.78**	2.00	0.30	**4.08**
CEMT class IV, 0 cont. layer	3.89					**3.89**	2.50	0.30	**1.69**
CEMT class IV, 1 cont. layer	0.60	2.59			0.70	**3.89**	2.50	0.30	**1.69**
CEMT class IV, 2 cont. layers	0.60	2.59	2.59			**5.78**	2.50	0.30	**3.58**
CEMT class IV, 3 cont. layers	0.60	2.59	2.59	2.59		**8.37**	2.50	0.30	**6.17**

[47] For simplification reasons, the draft is considered stable and independent of the actual loading of the inland vessel with containers. The actual draft(s) will be determined as part of the work in task T4.2 “Uncrewed vessel concept development”.

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6 POINTS OF INTEREST IN USE CASE 1

6.1 INLAND WATERWAYS

The inland waterway network of the Use Case 1 area predominantly centres around Greater Amsterdam and the Rhine-Meuse corridor until Europe's largest seaport in Rotterdam. In addition, the two regions are interconnected with a number of inland waterways, which run through the Randstad region with various capillaries of different sizes. It has to be noted that the region is endowed with plenty of transport nodes and corridors of all transport modes – busy roads and highways, well-utilised railways connecting the region with other parts of the country as well as Belgium and Germany, a busy airport for passenger and freight traffic, and very dense inland waterway network including a series of large seaports and many inland ports.

From the northern end of the province Noord-Holland to the southern Dutch-Belgian border in the provinces of Zeeland and Noord-Brabant, an inland waterway network of a total length of 2,036 kilometres is situated. 44.45 percent of this network belong to the small inland waterways of CEMT classes I to IV, equalling a total network length of 896 kilometres. The network is transversed from west to east with both Lek (incl. Nieuwe Maas, Oude Maas, and Nieuwe Waterweg) and Waal (Rhine) and connected to the south with the Scheldt-Rhine Canal. From the Waal in the east, its northern distributary Nederrijn is connected with the Amsterdam-Rhine Canal which connects Amsterdam to the Rhine-Meuse Corridor. From Amsterdam, the Noordzeekanaal is the connection to the North Sea in the west. Further south, several arms of the North Sea permeate the southwestern part of the Use Case 1 area, which is congruent with the territory of the Kingdom of the Netherlands. To these arms belong Haringvliet, Hollands Diep, Volkerak, Grevelingen, Oosterschelde, and Westerschelde. The entire inland waterway network of the Use Case 1 area is shown in Figure 6-1 while the lengths of the different waterway classes in the considered geographic area are presented in Figure 6-4.

On analysing the CEMT classes of the waterways in the considered geographic area, it becomes evident that there is a clear separation between the outer ring around the Randstad region, which consists of the Noordzeekanaal, the Amsterdam-Rhine Canal, the Waal-Meuse conjoint stream, all inland waterways of CEMT class VI, and its inner part with partly significantly smaller waterways. The same as for the outer ring applies to the waterways further south leading to the sea arms of Haringvliet and Hollands Diep as well as the Scheldt-Rhine Canal connecting the region to Antwerp. Within the outer ring, most inland waterways belong to CEMT classes II and III, with a few exceptions from class V. Similarly, the inland waterways north of the ring range from CEMT classes I to V. Figure 6-2 illustrates the CEMT classes of the inland waterway network of the Use Case 1 area.

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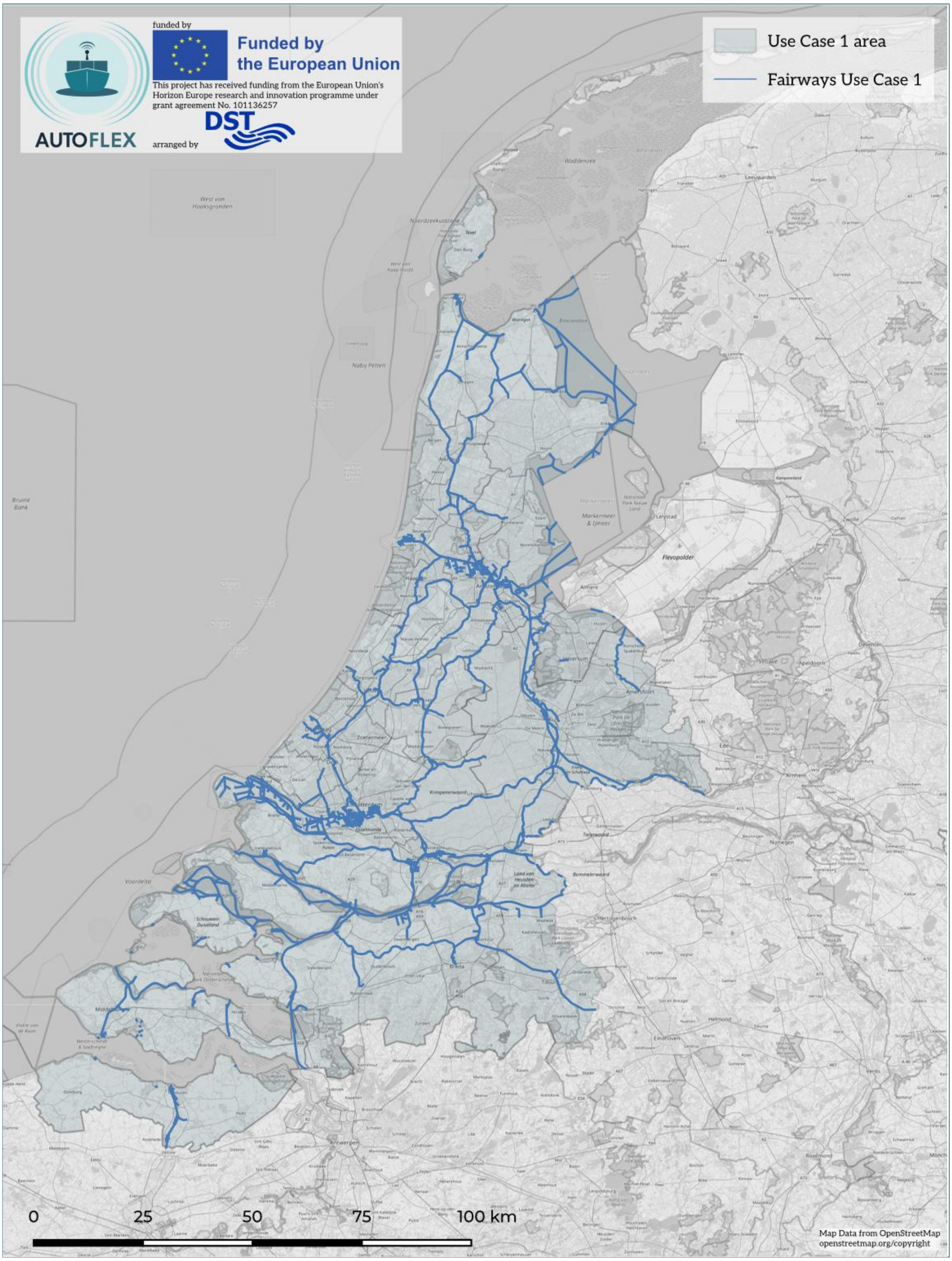

Figure 6-1: Inland waterways in the Use Case 1 area[48]

[48] excl. class 0 and uncategorised inland waterways

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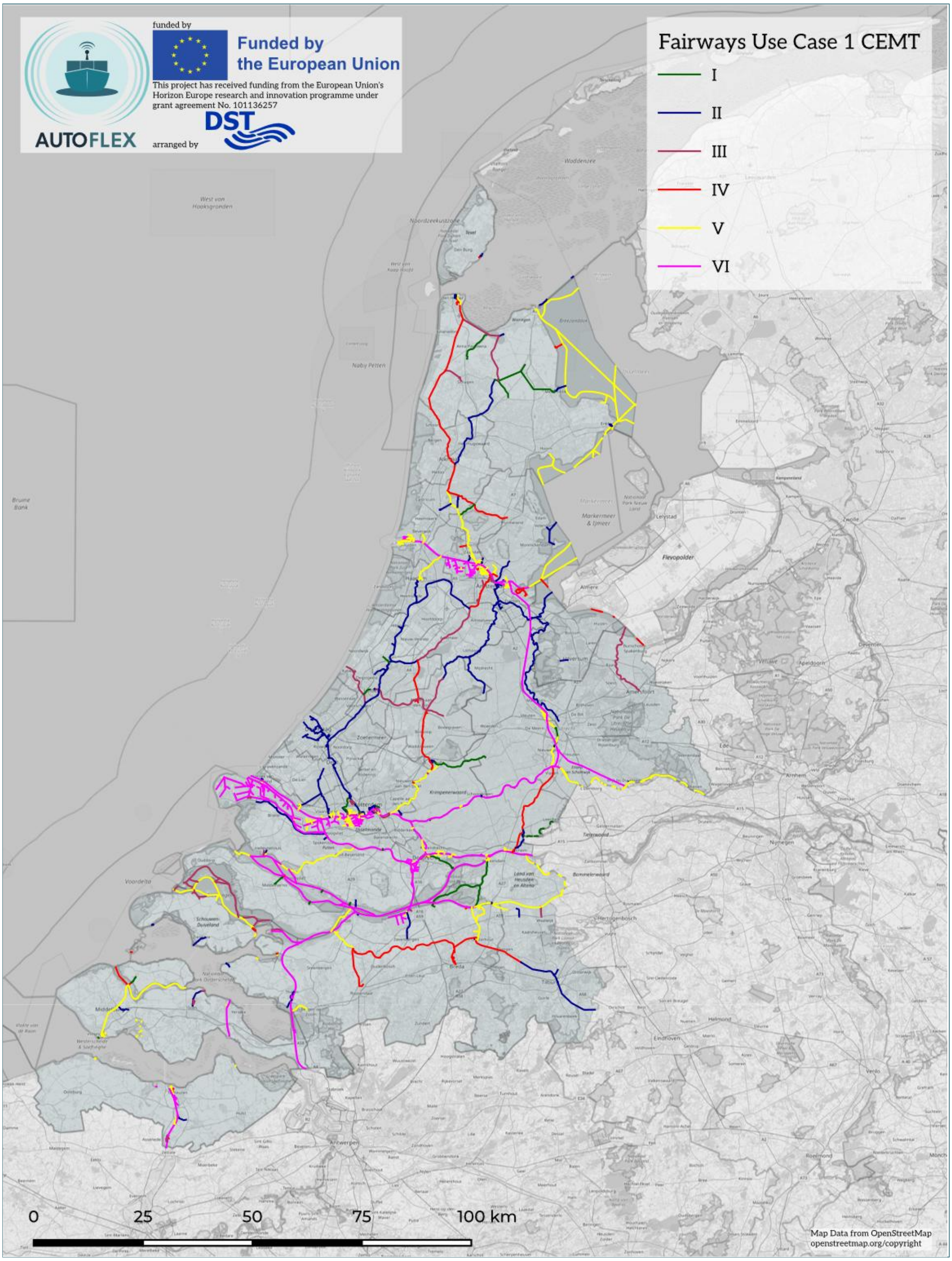

Figure 6-2: CEMT classes of inland waterways in the Use Case 1 area

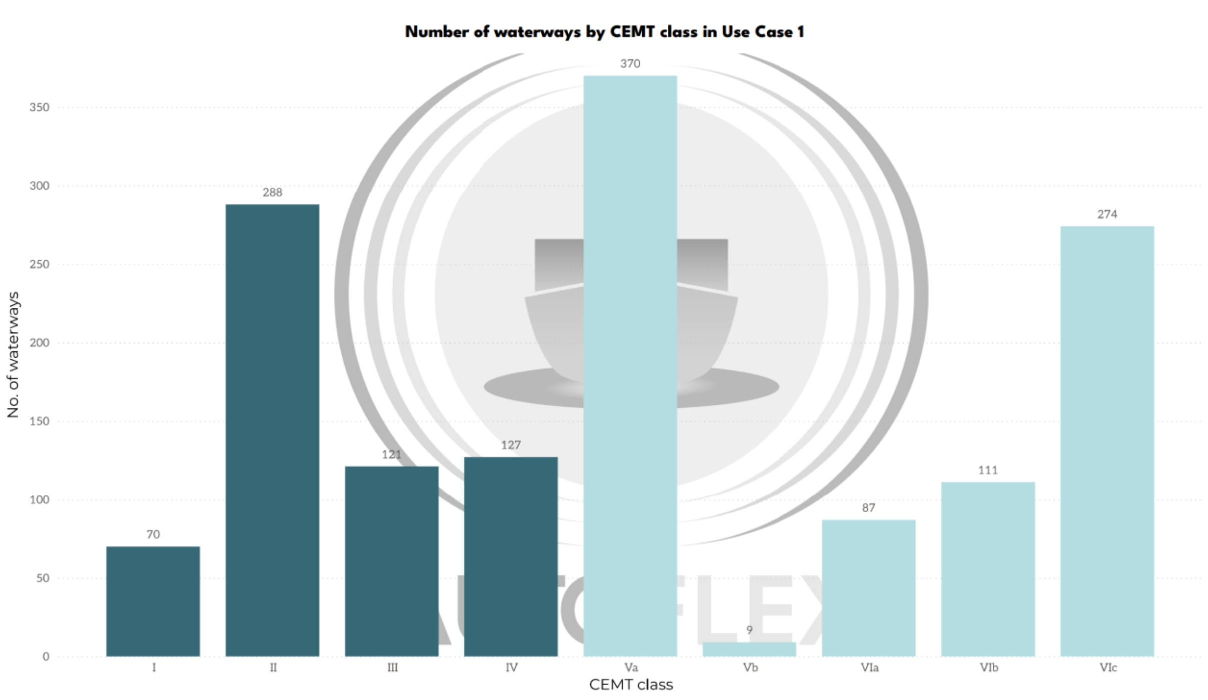

Figure 6-3: Number of inland waterways in the Use Case 1 area per CEMT class

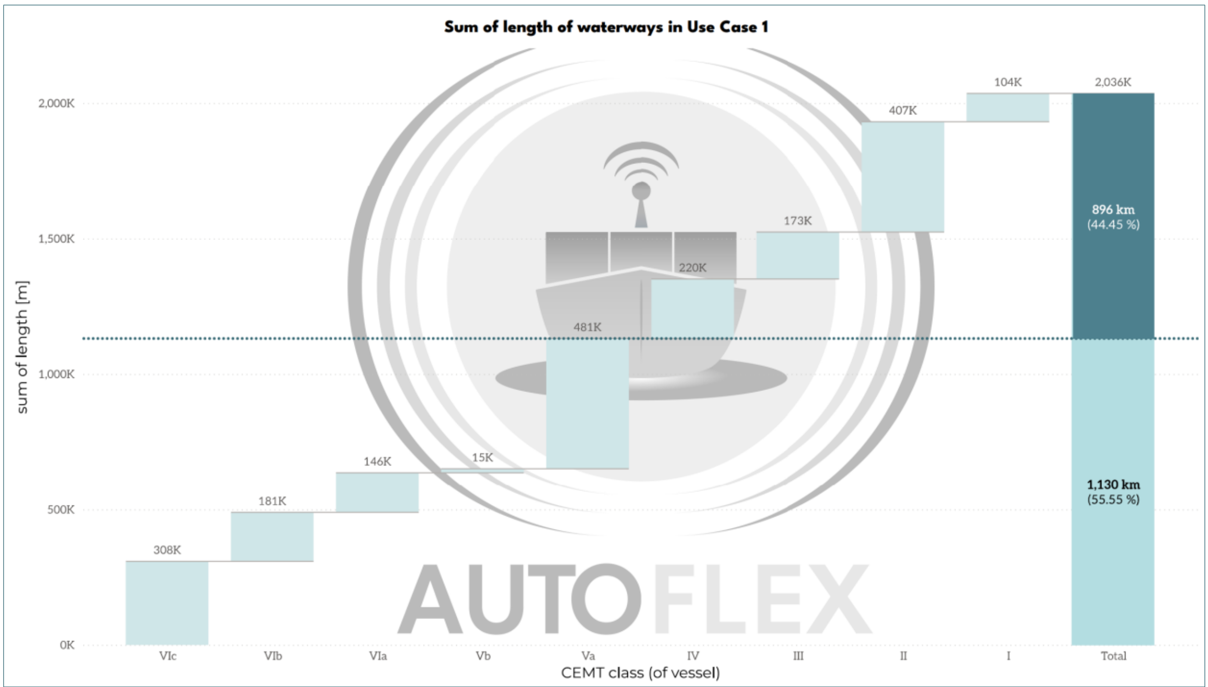

Figure 6-4: Total length of inland waterways in the Use Case 1 area per CEMT class

Most of the inland waterways of the considered area belong to CEMT classes VI (with 472 waterways) and V (with 379 ones) while the total number of small waterways in the region amounts to 606 waterways. In combination with the above-mentioned length, the average length of a CEMT class I waterway in the Use Case 1 area is nearly 1.5 kilometres long. Similarly, the class II and III waterways are approximately 1.4 kilometres long. In the case

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of CEMT class IV waterways, the average length is even higher with more than 1.7 kilometres. The average length of all inland waterways in the considered area amounts to nearly 1.4 kilometres as well. A different picture is derived from the analysis of the mean values: All four CEMT classes of the small waterways feature a median length of 450 to (more than) 650 metres whereas the median lengths of the CEMT class V and VI waterways lie between (nearly) 500 and 800 metres. So, in both cases, a large number of small stretches is outnumbered by a few long or even very long stretches – per CEMT class (see Table 6-1).

The aspect of the total and average length of the inland waterways in the considered geographic area is directly related to the operation of the small, flexible, automated, zero-emission inland vessels. The network density foots on the cumulated length of the individual inland waterways and the geographic dispersion throughout the entire use case area.

As the AUTOFLEX project foresees designs of inland vessels of the CEMT classes I to IV, those vessels are used as reference vessels when considering the total network length and coverage. Thereby, it becomes evident which part of the service area can be covered by which vessel variant. Moreover, a look at the respective network reveals the density level accessible for the respective vessel.

A CEMT class V inland vessel can only travel on the above-mentioned ring between Amsterdam, Utrecht, and Rotterdam as well as to the North Sea arms in the southwest and to Antwerp beyond the southern border of the Netherlands.

A CEMT class IV inland vessel facilitates isolated additional routes, e. g., from the southern part of the ring to Alphen aan den Rijn, a city situated between Amsterdam and Rotterdam, and from the northern part of the ring to Den Helder at the northern tip of the province Noord-Holland.

By using a CEMT class III vessel, the city of Leiden, situated west of Alphen aan den Rijn, becomes accessible. Moreover, it is possible to sail from Amsterdam to Rotterdam without having to use the outer ring. Such connections represent the first isolated relations within the considered region off the outer ring.

A CEMT class II vessel represents the biggest extension of the network with several waterways within the ring becoming accessible. Particularly, a number of longitudinal connections between the northern part of the ring and its southern counterpart is opened up thereby. Likewise, the southeastern part of the Use Case 1 area, which equals an area in the southern province of Noord-Brabant, is accessible.

A CEMT class I vessel hardly brings a measurable effect of the inland waterway network with merely some minor extensions of the existing network.

In the following figures, the network accessible for an inland vessel of the CEMT classes I (see Figure 6-9), II (see Figure 6-8), III (see Figure 6-7), IV (see Figure 6-6), and V (see Figure 6-5) is shown. Particularly the last figure shows the outer ring enclosing the core area of the Randstad region vividly. The above-mentioned observations are mirrored by the total lengths of the inland waterways per CEMT class in the Use Case 1 region (see Figure 6-4). Furthermore, it is striking that the smaller waterways are not useful for a better cross-border connection to the region of Flanders in the north of Belgium but rather contribute to a better service coverage off the main waterway corridors of the CEMT classes V and VI, both within the Randstad region and outside the ring.

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Table 6-1: Average and median lengths of inland waterways in the Use Case 1 area per CEMT class

CEMT class	median length [m]	average length [m]
I	571	1,488.93
II	655	1,414.78
II	454	1,433.05
IV	540	1,729.72
V a	558	1,299.45
V b	492	1,658.11
VI a	801	1,678.59
VI b	761	1,628.47
VI c	662	1,125.42
Total	**611**	**1,397.14**

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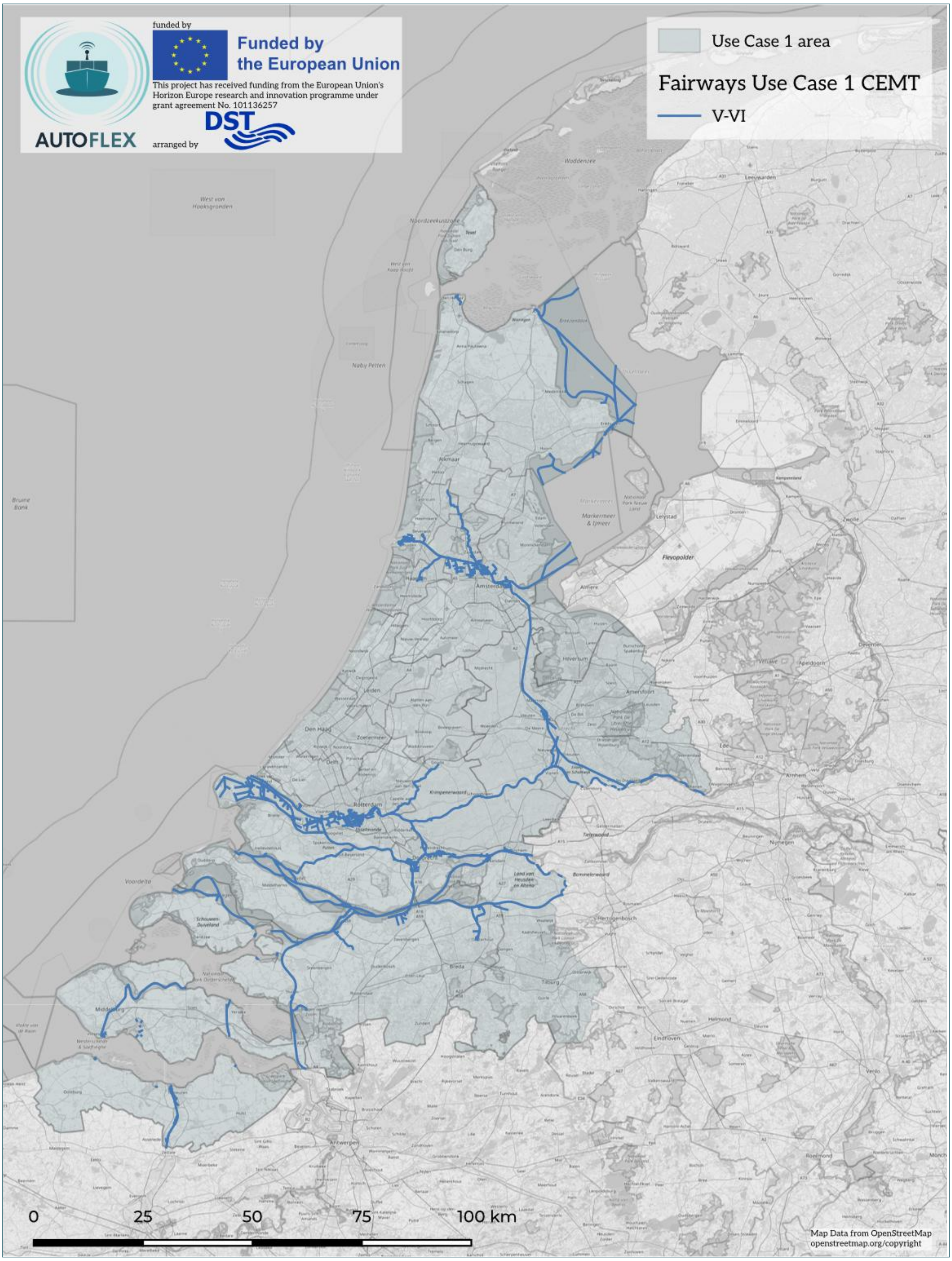

Figure 6-5: Inland waterways in the Use Case 1 area accessible for a class V vessel

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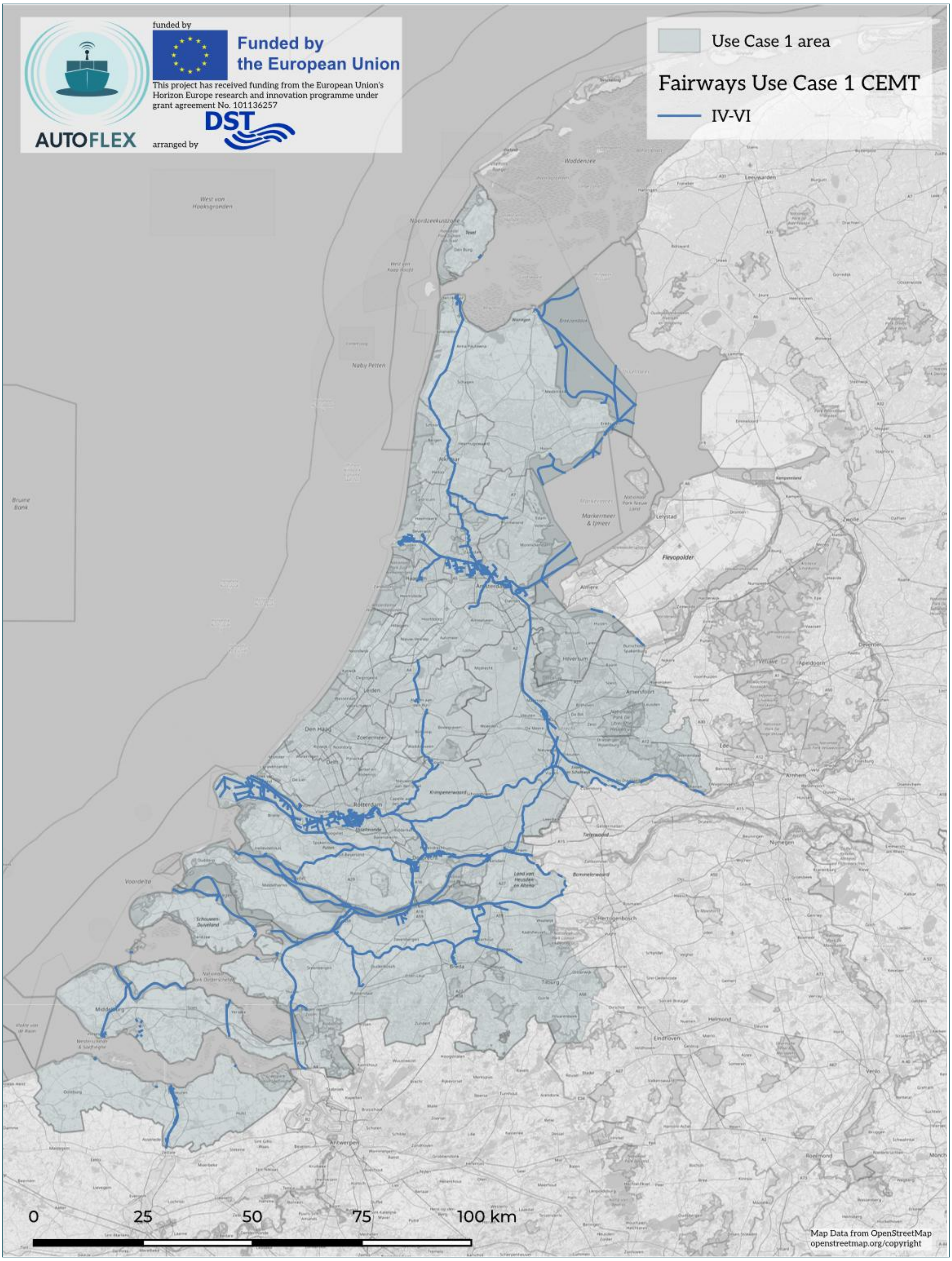

Figure 6-6: Inland waterways in the Use Case 1 area accessible for a class IV vessel

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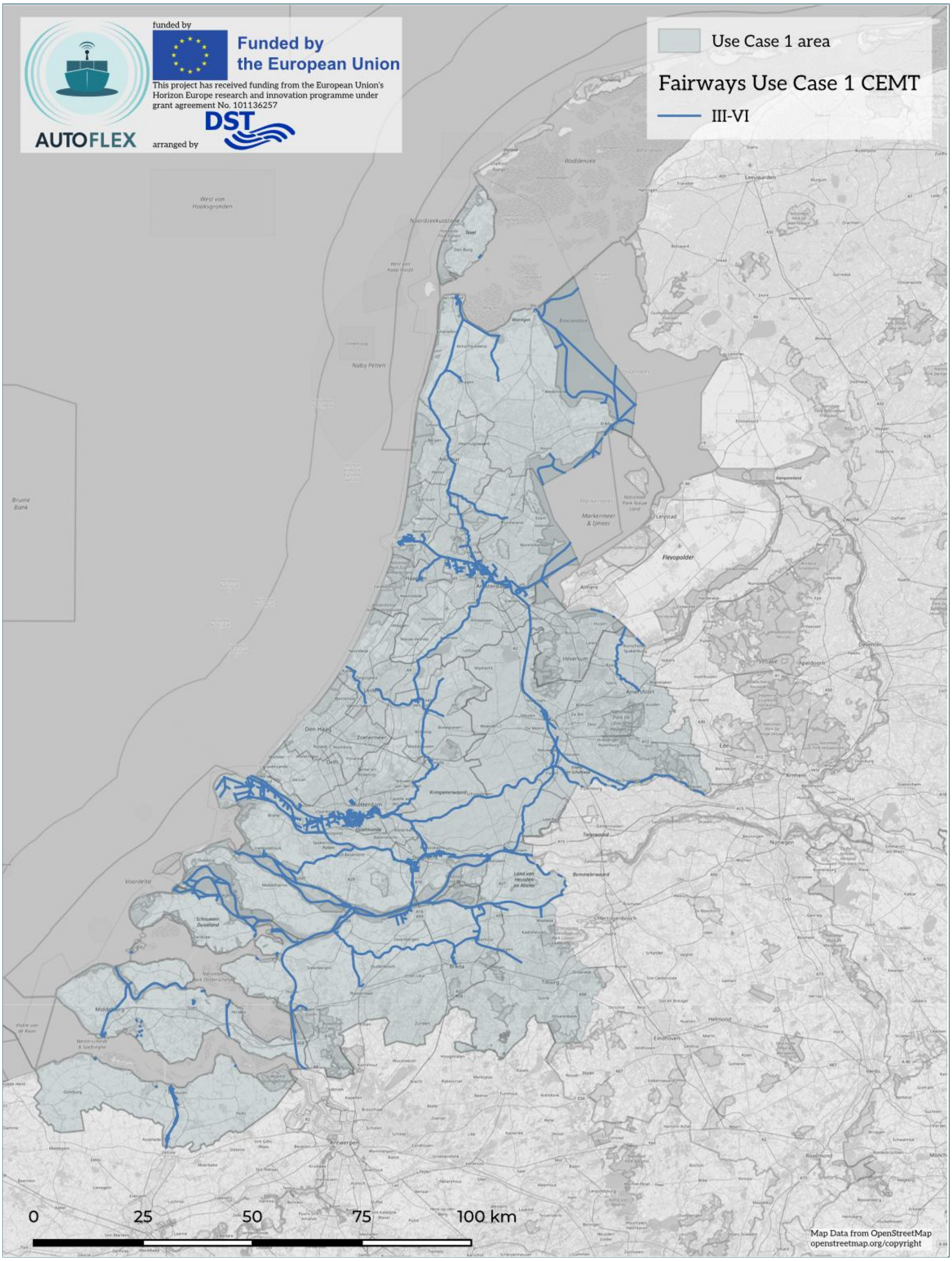

Figure 6-7: Inland waterways in the Use Case 1 area accessible for a class III vessel

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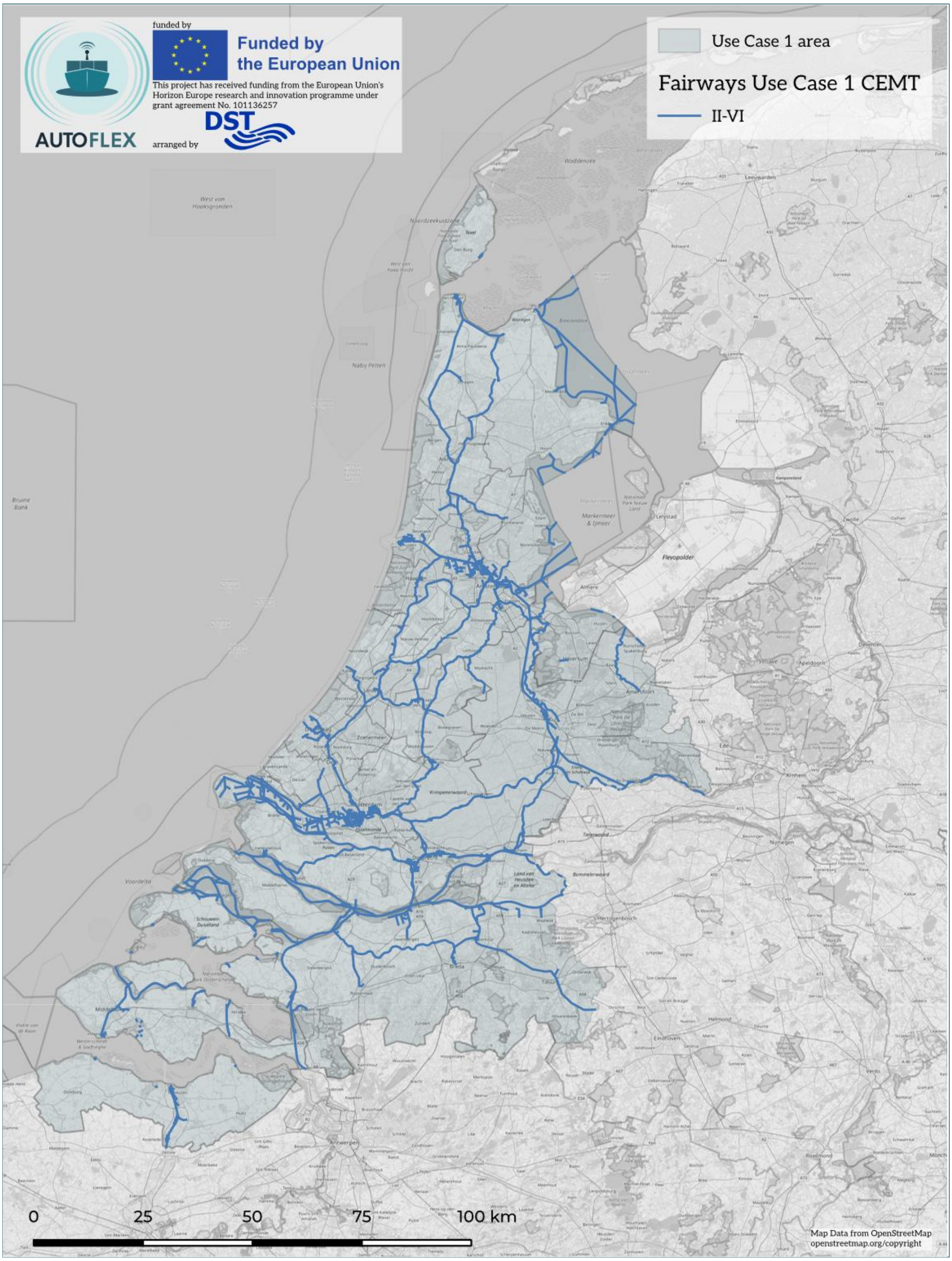

Figure 6-8: Inland waterways in the Use Case 1 area accessible for a class II vessel

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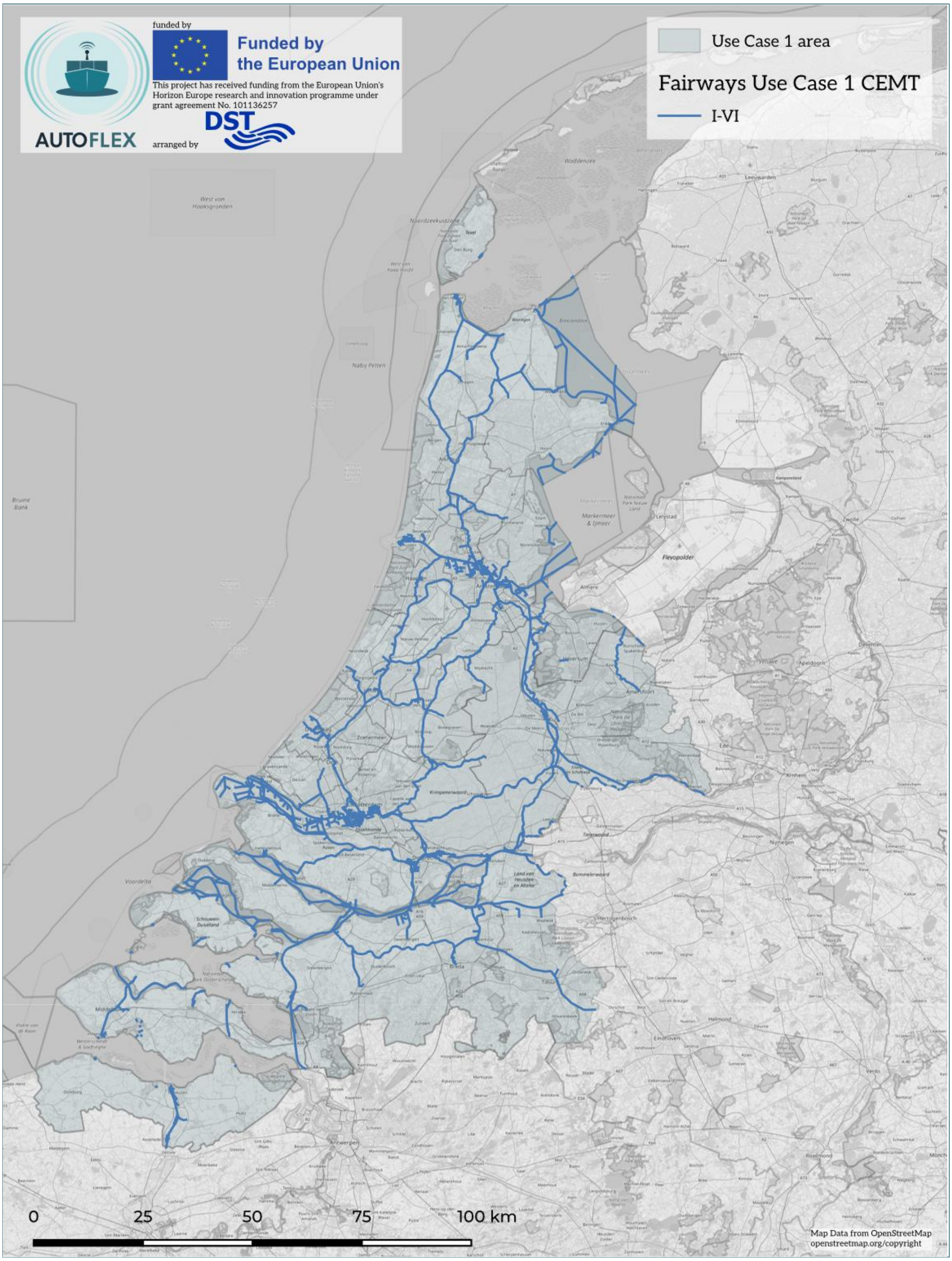

Figure 6-9: Inland waterways in the Use Case 1 area accessible for a class I vessel

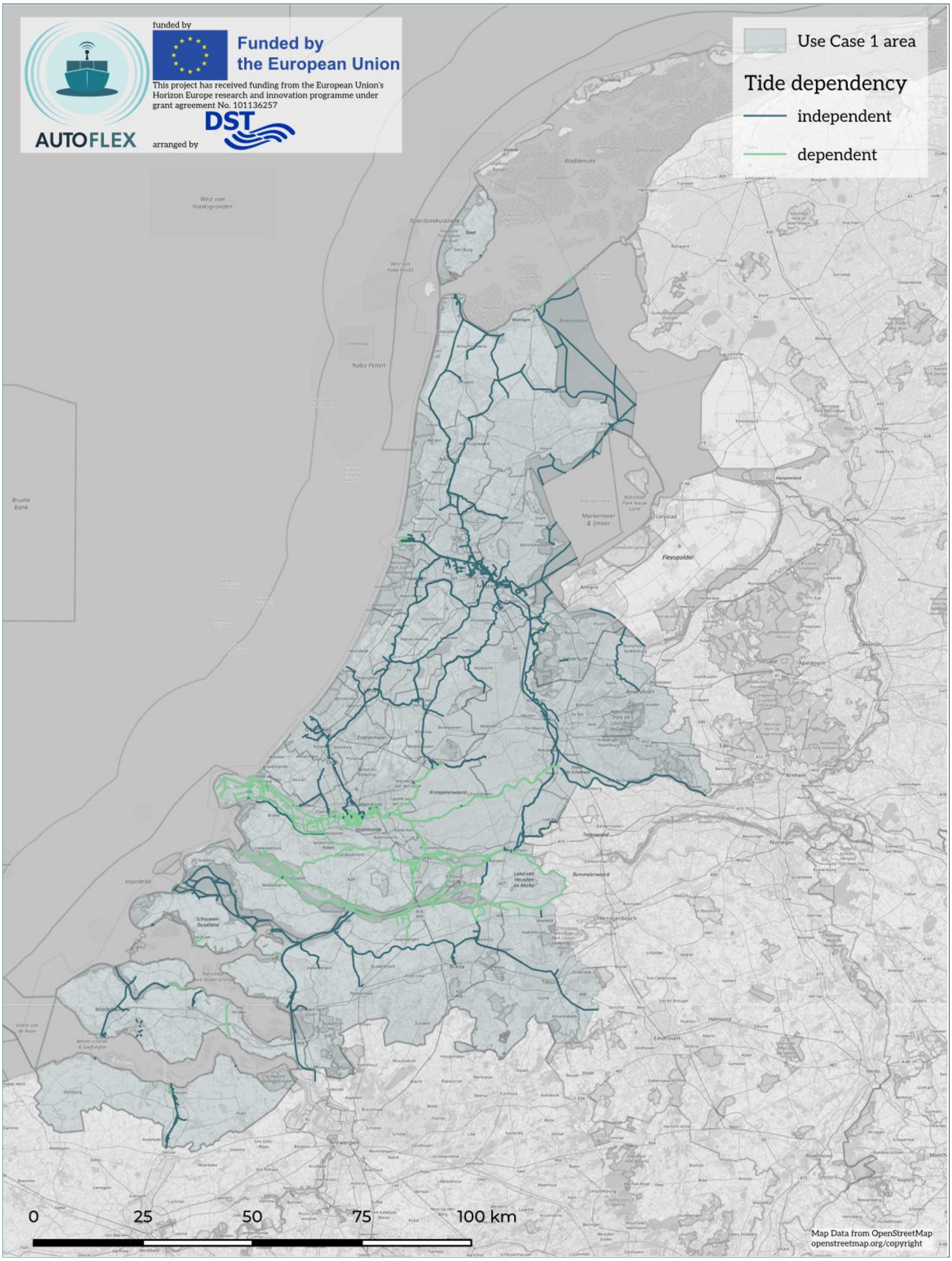

Figure 6-10: Tide-dependency of inland waterways in the Use Case 1 area[49]

[49] excl. class 0 and uncategorised inland waterways

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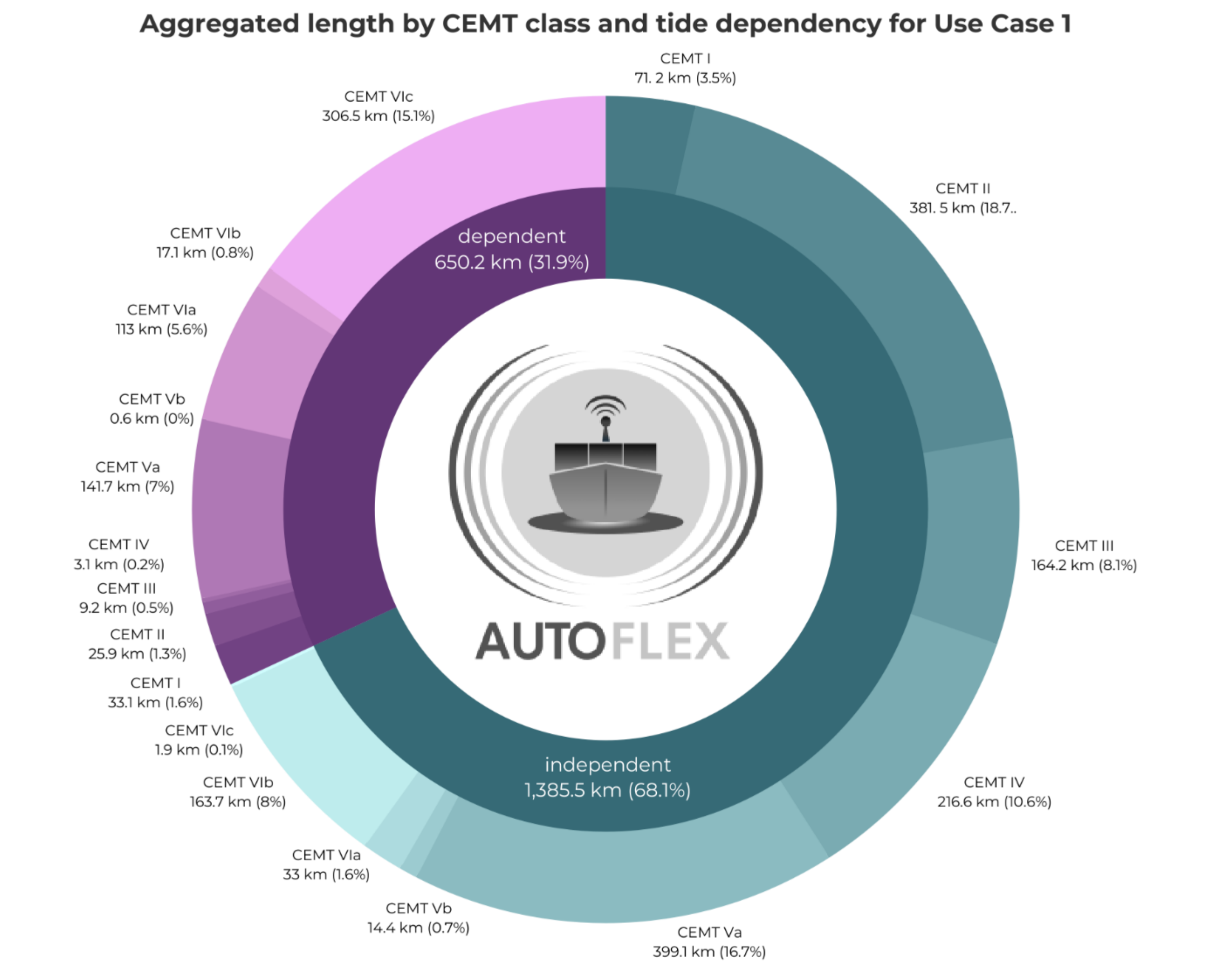

Figure 6-11: Proportion of tide-dependent inland waterways in the Use Case 1 area, differentiated by CEMT class

Given the exposure of the Netherlands to the element of water in general and to the North Sea in particular, the dependency of the inland waterway network on the influence of the tides appears as a relevant information. The map shown in Figure 6-10 reveals that the largest part of the network in the Use Case 1 area is independent of the tide whereas the southern part of the ring, more precisely, between Hoek van Holland, Rotterdam, and Utrecht, where the Meuse and the Waal rivers are flowing, is subject to tidal influence. The same applies to the sea arm encompassing Haringvliet and Hollands Diep which eventually connects to the above-mentioned Waal rivers in the southern part of the ring. As illustrated in Figure 6-11, the tide-dependency predominantly affects waterways of the CEMT classes V and more.

With respect to the permitted speed of an inland vessel on the different waterways, the ring belongs to the part of the inland waterway network which allows higher velocities whereas lower speed limits are valid in the inner part of the ring, in which the smaller waterways can be found. The sea arms in the southwest belong to the stretches with higher velocities as well. A CEMT class IV waterway can be considered as a waterway with a medium speed permission. Figure 6-12 shows the speed limits on the entire waterway network.

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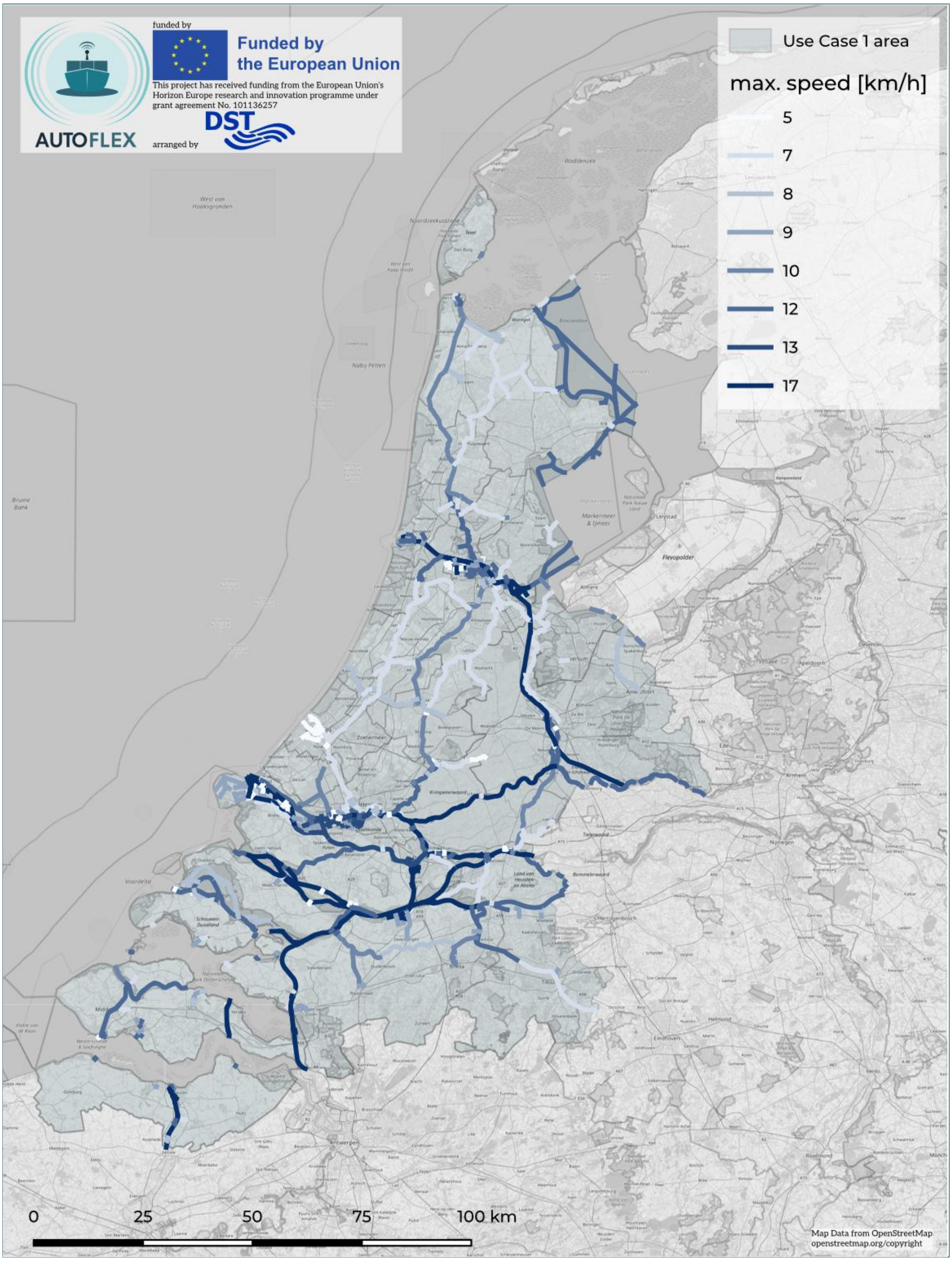

Figure 6-12: Speed limits on the inland waterways in the Use Case 1 area[50]

[50] excl. class 0 and uncategorised inland waterways

6.2 BERTHS AND TRANSSHIPMENT POINTS

The transhipment points in the Use Case 1 area amount to 1,721 terminals in total. The considered terminals are related to freight transport and transshipment as well as to passenger traffic. There exist 78 tank terminals in the considered geographic area, predominantly along the waterways in the Rhine-Meuse delta and in the vicinity of the chemical cluster between Rotterdam and Hoek van Holland. The 162 bulk terminals in the use case area are scattered throughout the entire region so that a real accumulation of such terminals cannot be recognised. Moreover, 184 container terminals are situated in the region, mainly on the outer ring around the Randstad region connecting Amsterdam, Utrecht, and Rotterdam. This corresponds to an eighth of all terminals in the considered area. The large majority of 1,149 terminals, equalling two thirds of all terminals, remains unspecified, possibly as it could not be clearly assigned to one category or information about cargo transshipment and handling activity is not given. Hence, they were treated as general cargo terminals. Apart from the freight-related terminals, another 148 ferry terminals are located in the region, many of which located in the eastern part of the Use Case 1 area. Figure 6-13 shows all terminals of the considered area while Figure 6-15 shows the share of each terminal type. As the focus of the AUTOFLEX project lies on waterborne container transport, the relevant terminals can be seen in Figure 6-14.

As can be seen in Figure 6-17, over 2,100 berths are available in the Use Case 1 area. As discussed earlier, the differentiation between the ones with transhipment facilities and those without such equipment is important to assess whether a particular berth qualifies for occasional or temporary transshipment. 1,100 transshipment berths are offset by 1,047 berths without any shoreside transshipment facility. Interestingly, most of the transshipment berths are located on the outer ring and in the northern province of Noord-Holland whereas the simple berths without such facilities can be found elsewhere. It has to be noted though that a large accumulation of such simple berths can be found in Greater Amsterdam and between Rotterdam and Hoek van Holland. On taking a closer look at the berths, it becomes evident that most berths are designed for CEMT classes V and VI whereas dedicated berths for small inland vessels are in the minority (see Figure 6-16). This means that the choice is large enough for small inland vessels as they are not confined to using the dedicated berths for small vessels but also can berth at berthing locations designed for larger vessel units. Another interesting aspect is the assignment of berths to terminals. Merely, 48 transshipment berths and 54 berths without any transshipment facility are assigned to a terminal in the Use Case 1 area. So, the vast majority of berths are not directly linked with any terminal operation, even if they happen to be transshipment berths. The numbers are to be treated with utmost care and diligence, as the risk of erroneous, faulty, or missing data cannot be excluded.

In order to show the details of berths or terminals (and other transhipment points) in their geographic and nautical context, it is important to observe the actual surrounding of both types of PoIs. Figure 6-18 shows the example of the Dutch city of Den Haag, in which two bulk terminals and a few berths are visible along a CEMT class II inland waterway. On the contrary, Figure 6-19 presents the numerous terminals, multiple berths with and without transshipment facilities, and several inland waterways of the CEMT classes I to VI b.

The details of the 128 port cities in the Use Case 1 area (with their respective number of terminals and berths) can be found in Table A-2 in the Appendix.

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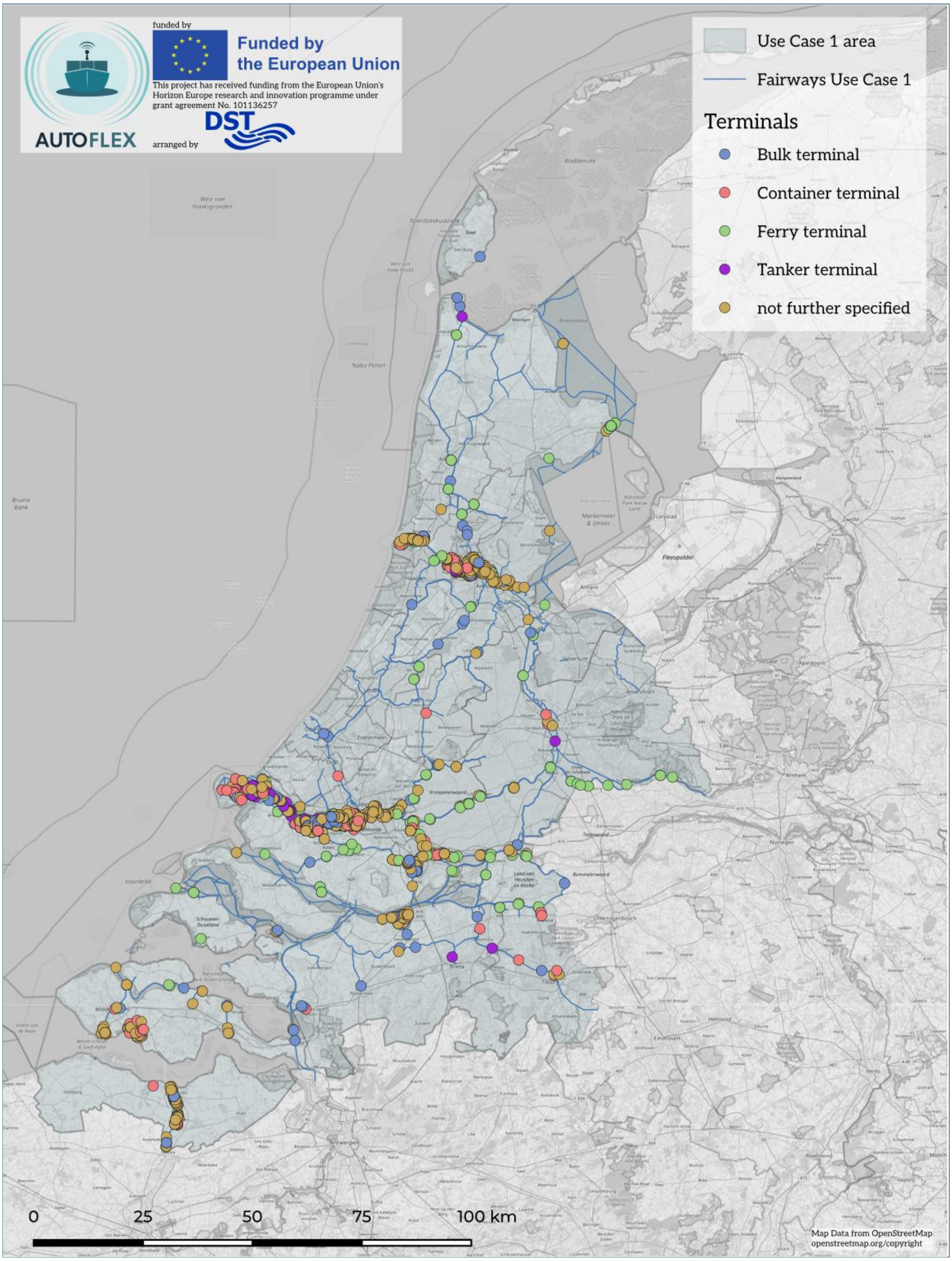

Figure 6-13: Types of terminals in the Use Case 1 area

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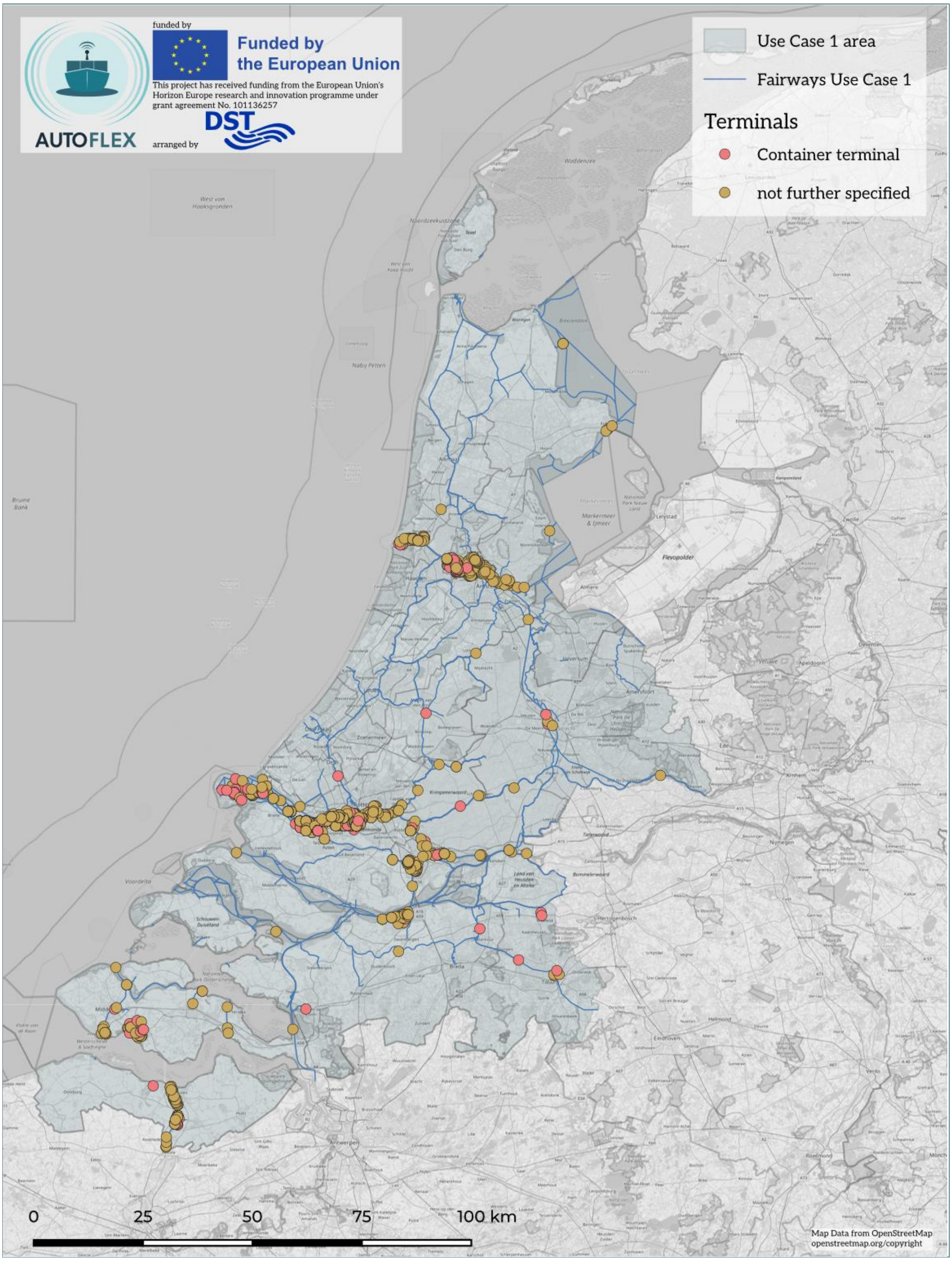

Figure 6-14: Container and uncategorised terminals in the Use Case 1 area

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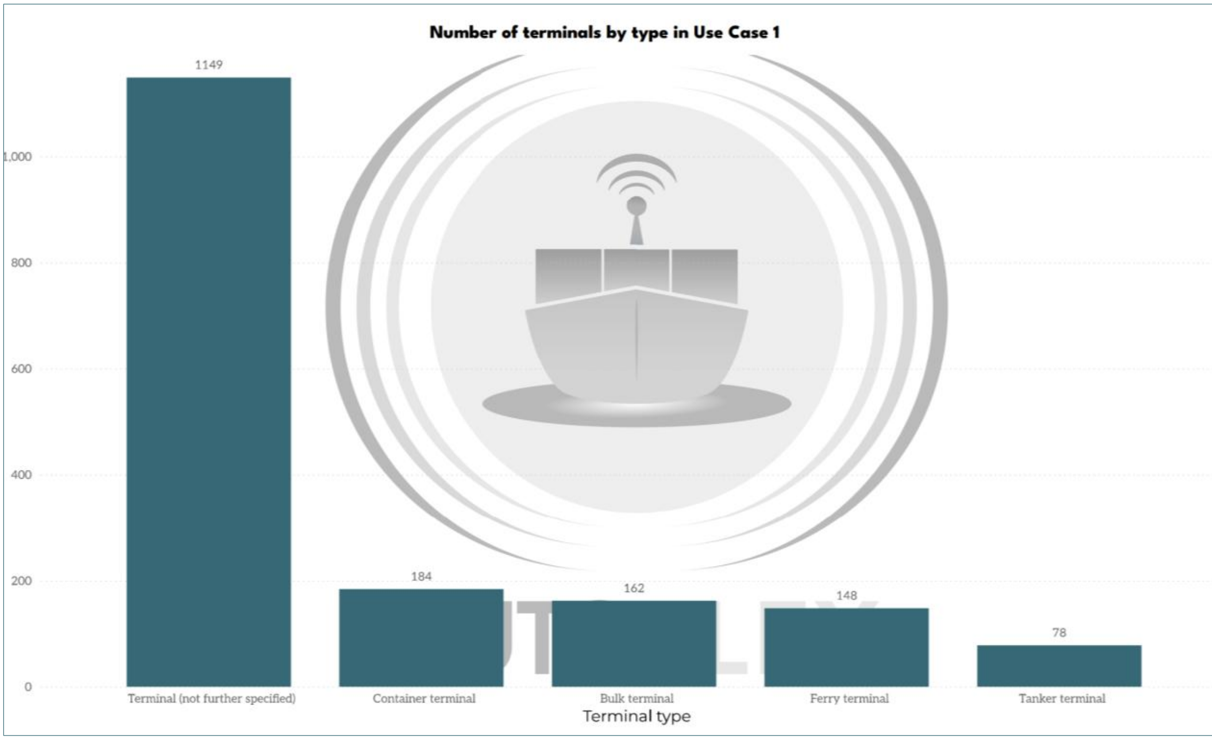

Figure 6-15: Proportion of terminals in the Use Case 1 area by type

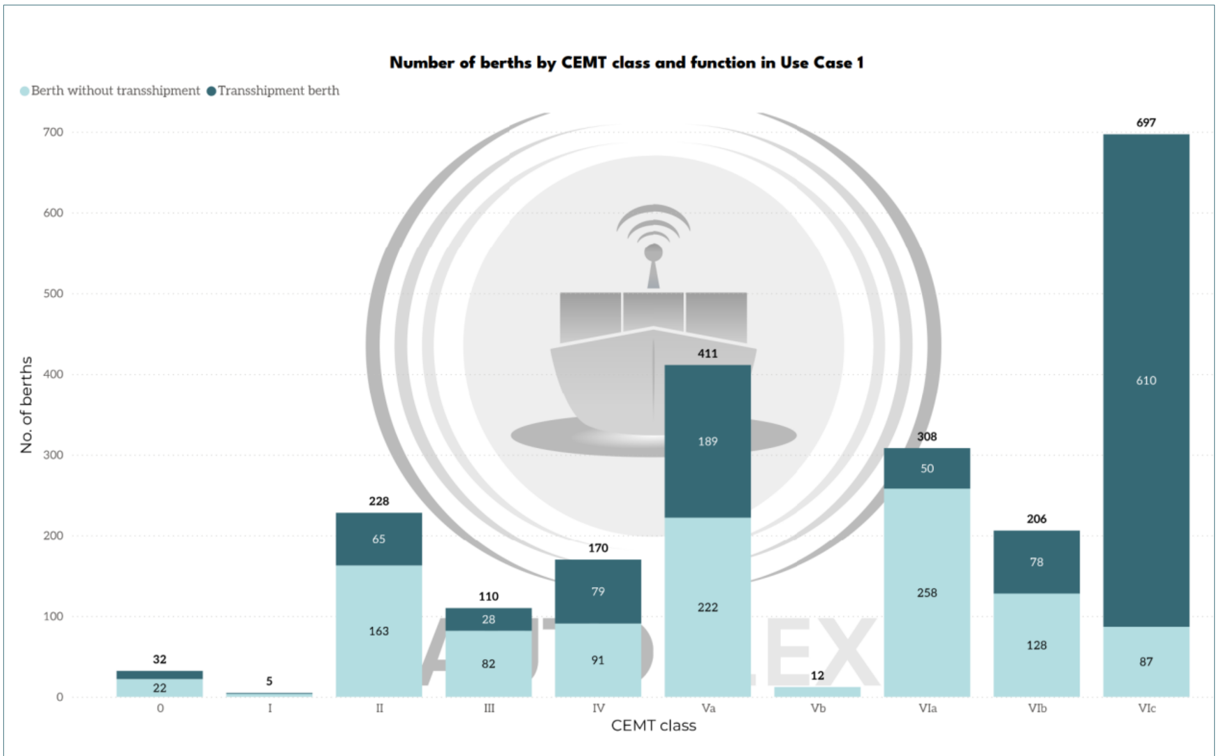

Figure 6-16: Number of berths with and without transshipment facilities per CEMT class in the Use Case 1 area

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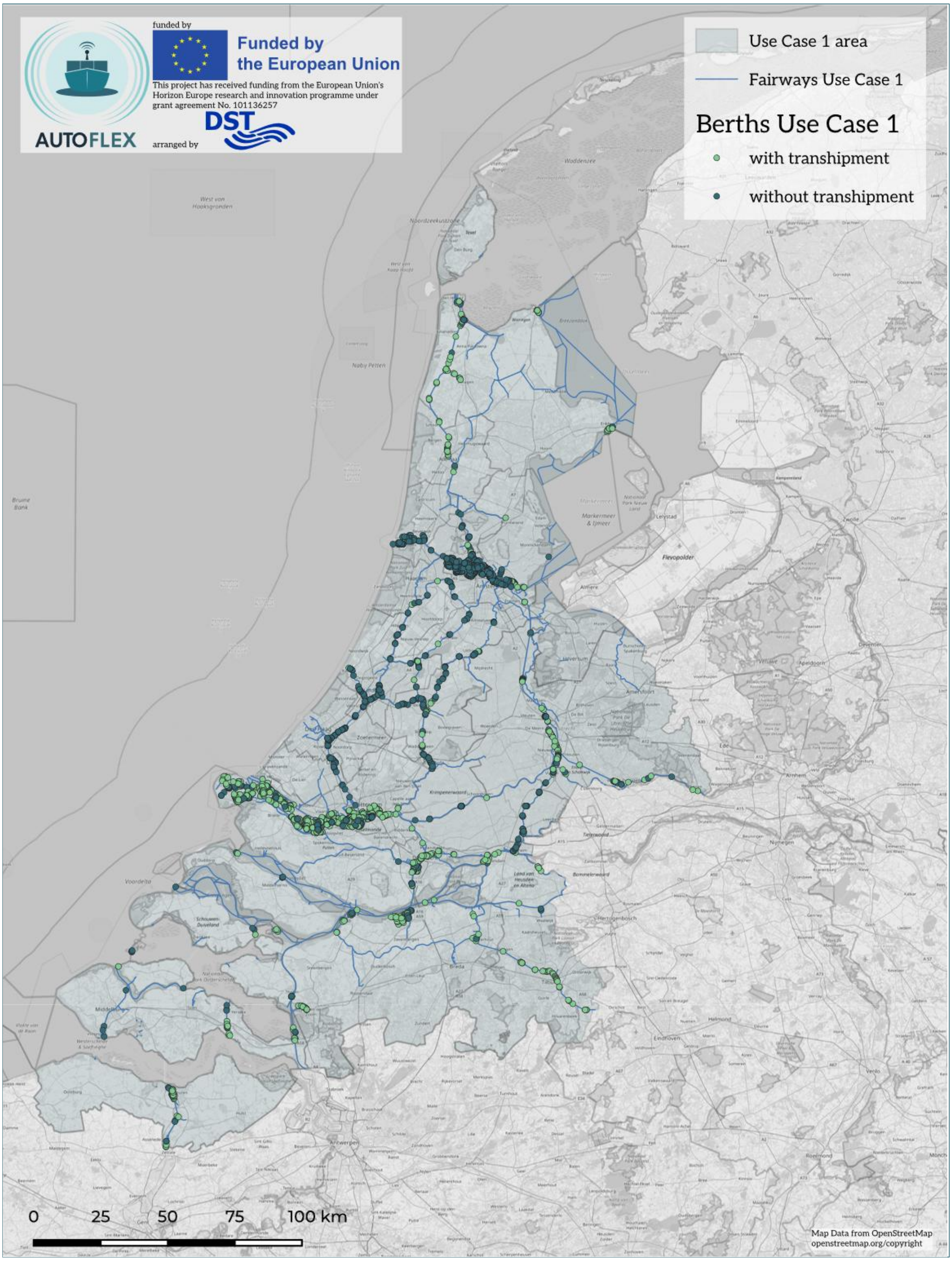

Figure 6-17: Berth types in the Use Case 1 area

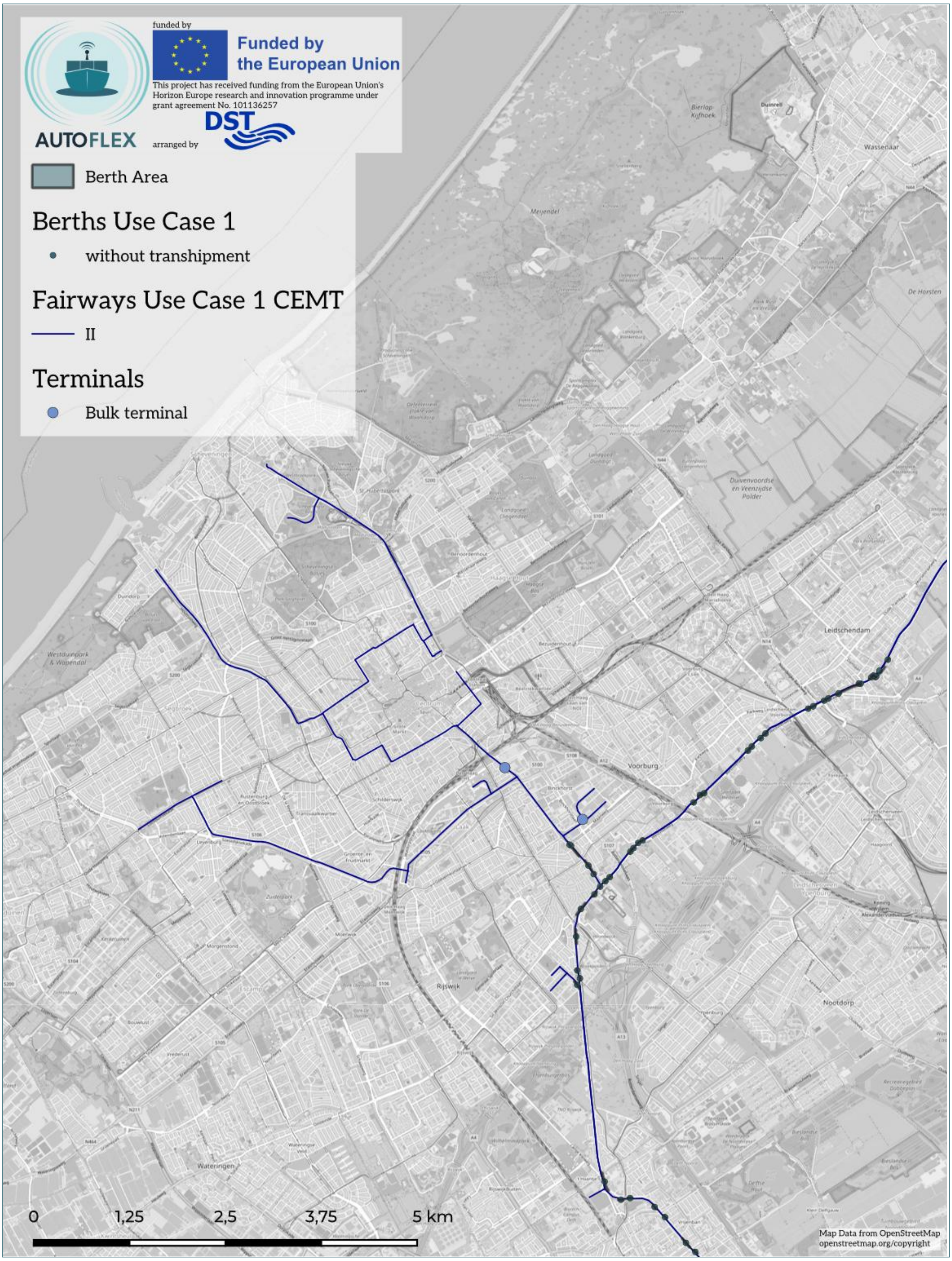

Figure 6-18: Terminals and berths in Den Haag, the Netherlands (NL332)

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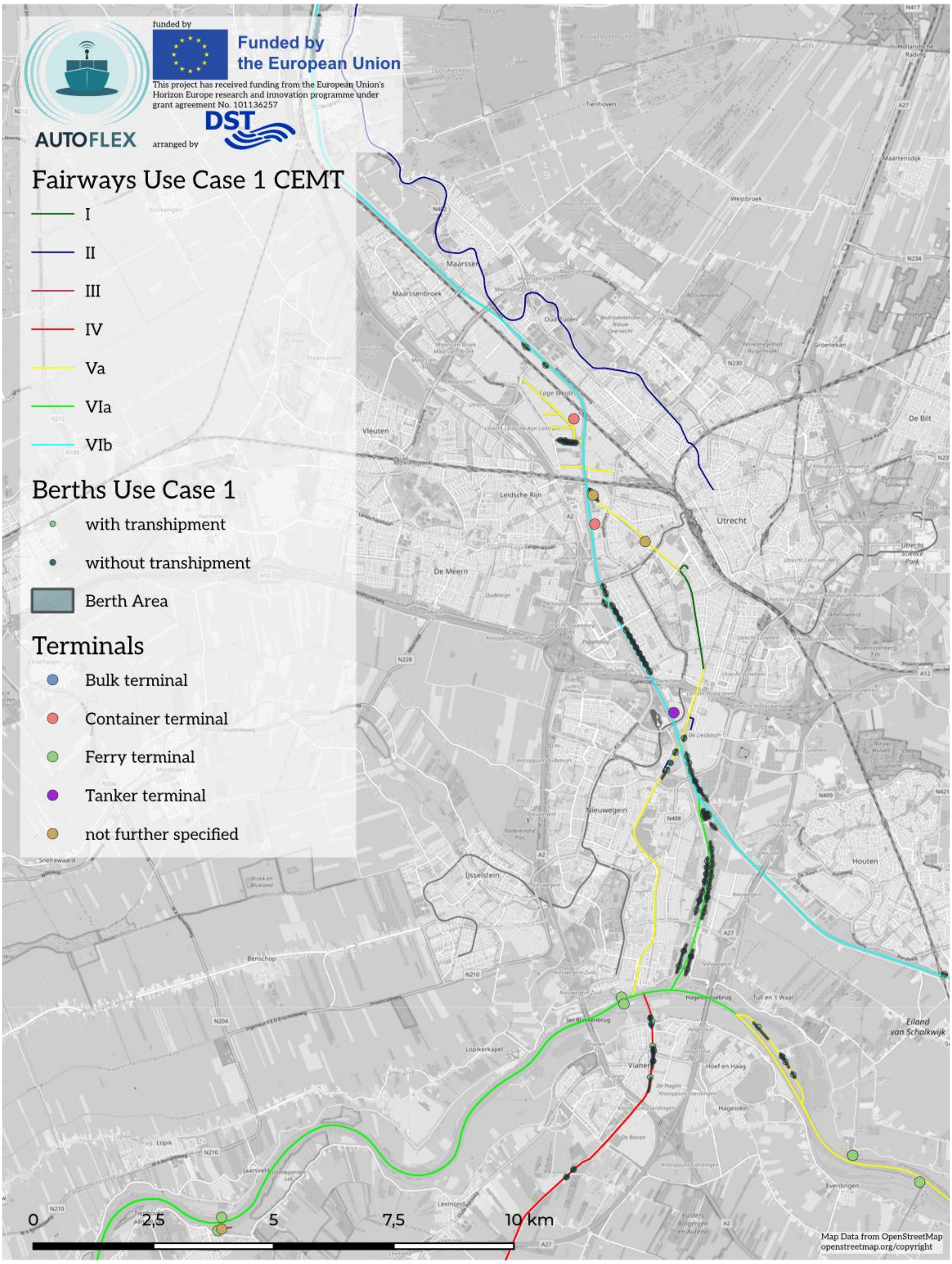

Figure 6-19: Terminals and berths in Utrecht, the Netherlands (NL310)

6.3 LOCKS AND WEIRS

The locks situated in the Use Case 1 area mostly revolve around the outer ring around the Randstad region (Figure 6-20). This is not surprising as most of the inland waterways in the region within the ring are canals without any major change of water levels. Accordingly, most of the locks occur at the intersection of the free-flowing rivers with the regulated canals and in geographic areas with topographical inclines and declines. Apart from the inner part of the ring, the locks are widely distributed over the area.

In total, 180 locks can be found in the Use Case 1 area, with 29 on unspecified inland waterways and 45 on CEMT-0 waterways. The remaining 106 locks are predominantly located on small waterways of the CEMT classes I to IV whereas 48 locks lie on the larger CEMT classes V and VI. So, approximately 59 percent of the locks are located on small inland waterways. Table 6-2 and Figure 6-21 show the distribution of locks per CEMT class in the considered geographic area.

The vast majority of locks exhibit exactly one lock chamber whereas locks with two or more chambers are the absolute exception. Figure 6-22 shows the distribution of the locks in the Use Case 1 area.

On looking at the shortest locks in the considered use case area, it becomes evident that the shortest five ones (in a list of locks sorted by vessel length in ascending order), with a permitted vessel length ranging from 24.50 metres to 37.30 metres, are smaller than the official CEMT class I threshold (of 38.50 metres). The next ones are more than 38.50 metres long and, thus, belong to CEMT class I. This means that the locks are certainly capable of accommodating inland vessels of CEMT class I (whereas the first five locks may be only able to do the same in case the vessels are shorter in length). Considering the Dutch class 0 for inland vessels of max. 38.00 metres length and max. 5.00 metres width, some of those may be able to pass the locks. The shortest locks in the Use Case 1 can be found in Table 6-3.

Similarly, only one lock among the narrowest locks in the analysed region is too narrow for any regular vessel, while four more belong to CEMT class I and all other locks in the Use Case 1 area belong to waterways of CEMT class II or higher. Table 6-4 lists the narrowest locks in the considered region.

As a result of analysing the locks with the smallest dimensions, it becomes evident that the largest portion of the locks in the considered region are small while a few are large enough to welcome larger inland vessels as well and even some others can even accommodate big seagoing vessels (see Figure 6-23). On focusing on the smaller locks as shown in Figure 6-24, which are supposed to handle small inland vessels, it becomes obvious that locks that may feature a chamber width higher than 5.05 metres (which would enable the passage of CEMT class I inland vessels) but only a chamber length of less than 38.50 metres which does not even allow the passage of CEMT class I inland vessels. Analogously, a series of locks feature a width of more than 6.60 metres (for CEMT class II inland vessels) but a length of less than 55.00 metres (for CEMT class II vessels). The number locks of the CEMT classes III and IV is comparatively low as the locks of the CEMT class V or higher are represented more frequently.

A total of 83 weirs are located in the Use Case 1 area. The weirs, on the contrary, are mostly located in the canal network within the ring or in the area north of Amsterdam. This appears logical as their primary function is the control of the water flow by stoppage and redirection.

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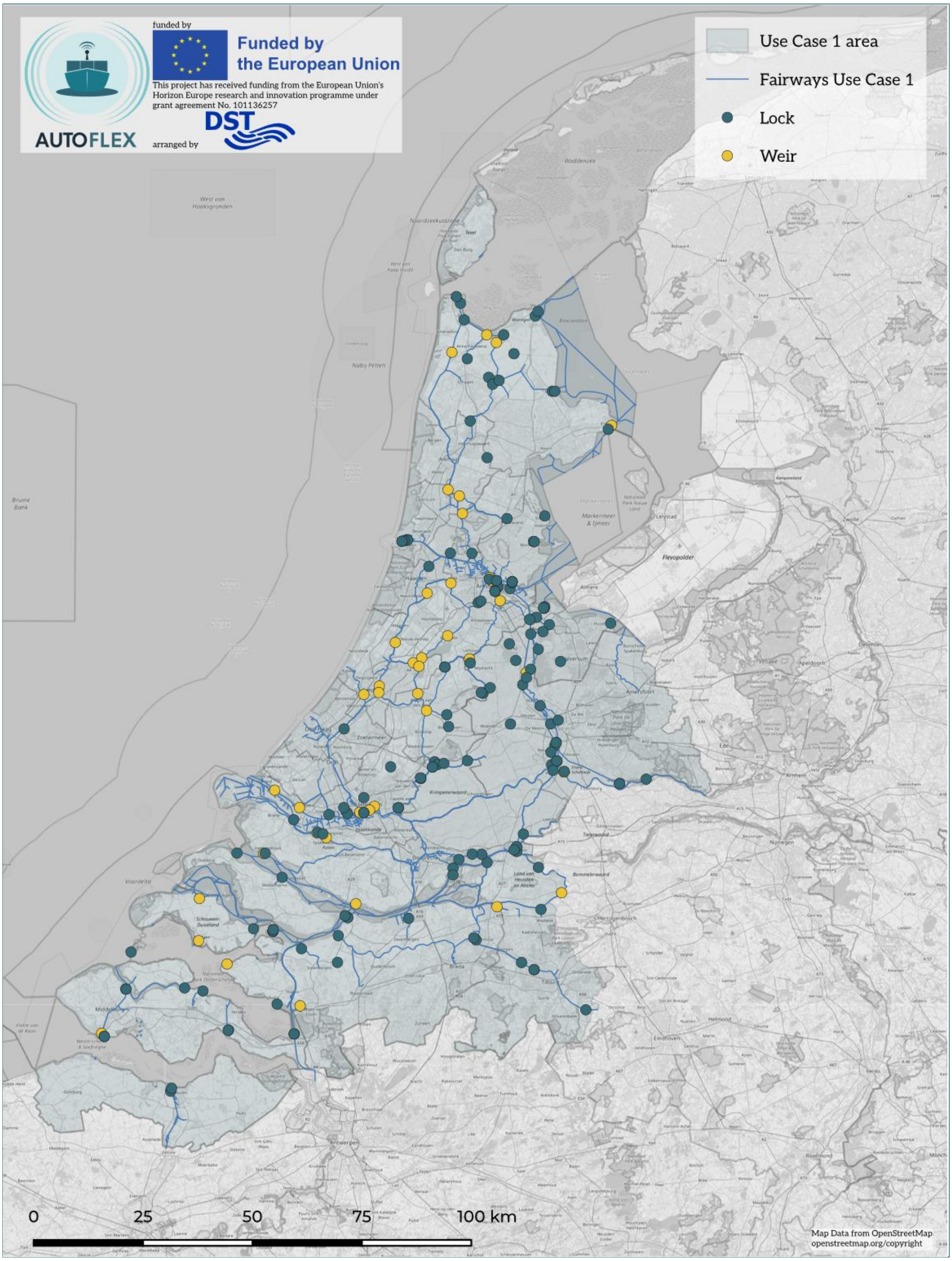

Figure 6-20: Locks and weirs in the Use Case 1 area

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Table 6-2: Number of lock chambers per CEMT class in Use Case 1 area

CEMT class	n/a	0	I	II	III	IV	V a	VI a	VI b	VI c	Total
Number of lock chambers	29	45	10	31	6	11	25	7	14	2	180

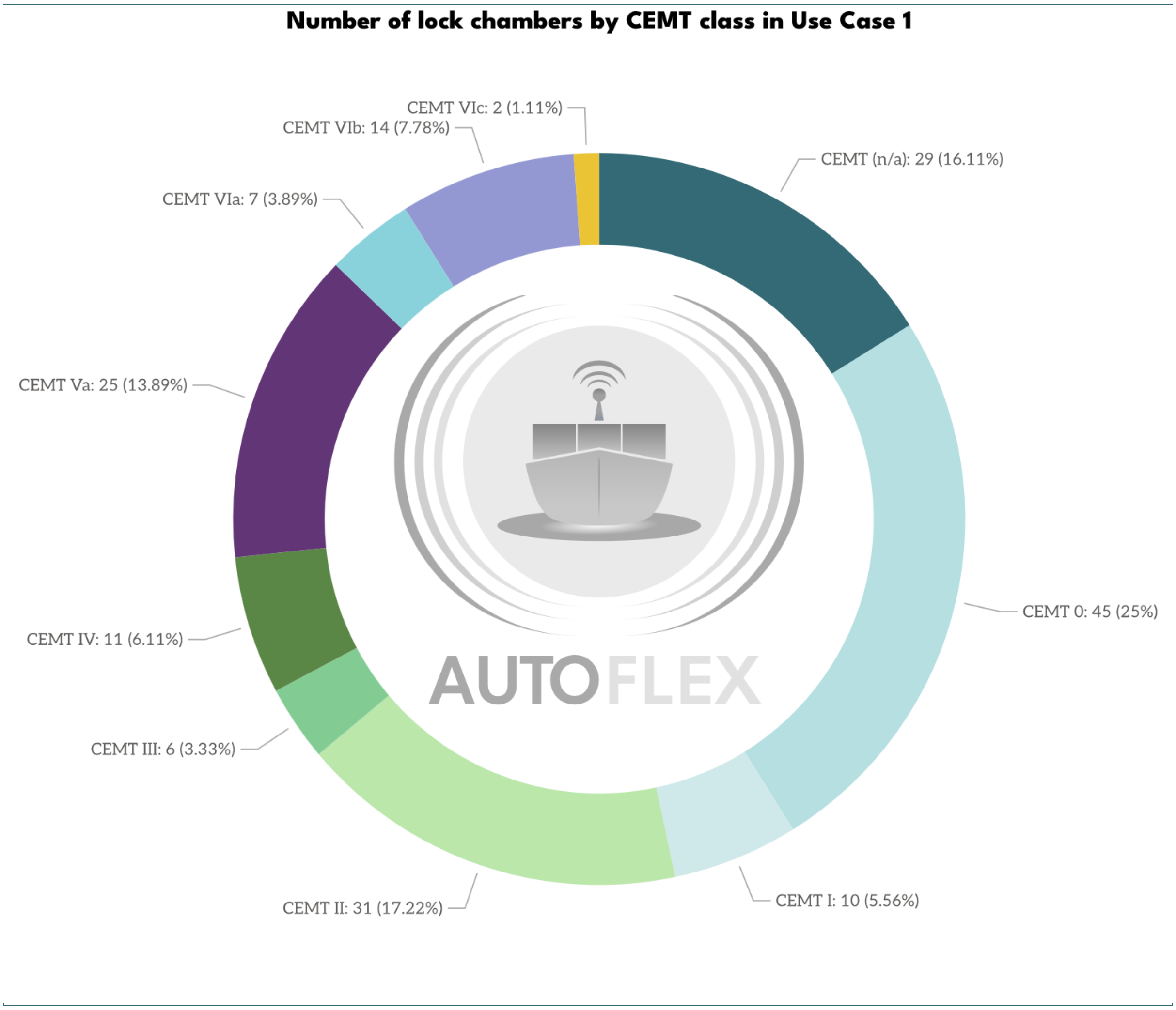

Figure 6-21: Number of locks per CEMT class in Use Case 1 area

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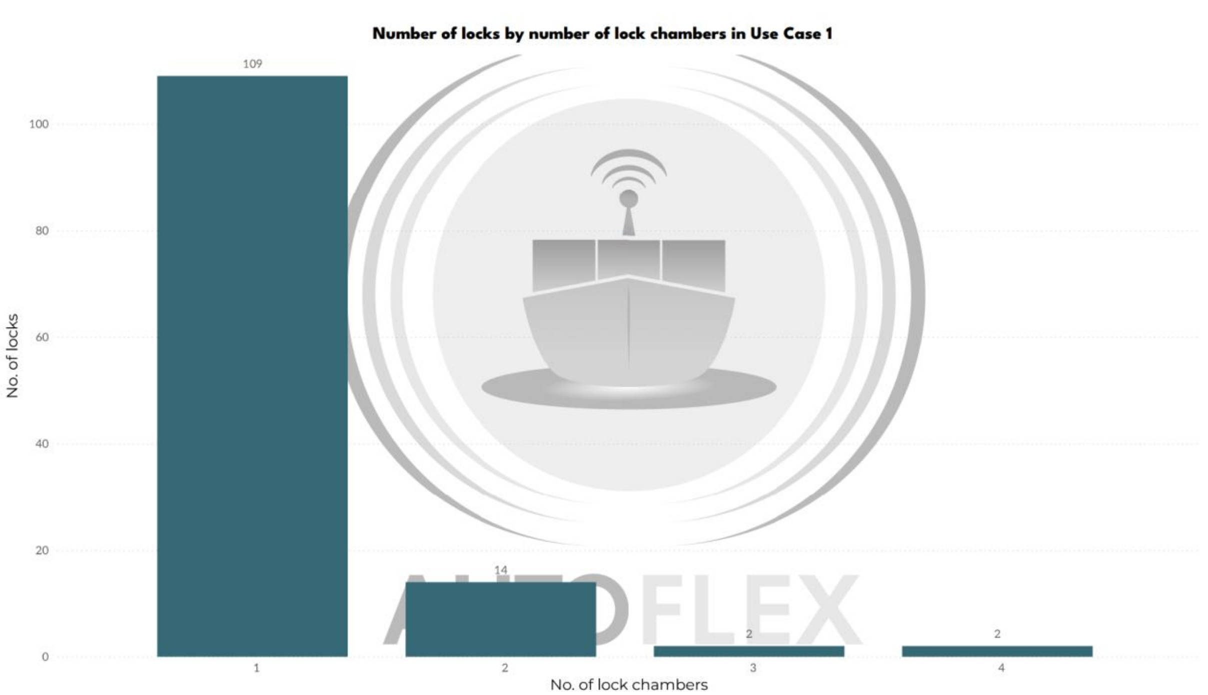

Figure 6-22: Number of lock chambers per lock in Use Case 1 area

Table 6-3: Shortest locks in the Use Case 1 area

Name	Permitted vessel length [m]	CEMT class
Waaiersluis	24.50	(0)
Klein kolk Tolhuissluis	25.00	(0)
Middelharnis, sluis	29.00	(0)
Zeedoksluis	31.70	(0)
Middenkolk Groote Zeesluis, Muiden	37.30	(0)
Ottersluis	39.00	I
Hellevoetsluis, sluis	40.00	I
Medemblik	40.00	I
Westfriescheslluis	42.00	I
Beurssluis	43.00	I

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Table 6-4: Narrowest locks in the Use Case 1 area

Name	Permitted vessel width [m]	CEMT class
Klein kolk Tolhuissluis	4.00	(0)
Sluiskolk 2 (O) bij Willem-I sluis	5.30	I
Kleine kolk Parksluizen	5.95	I
Waaiersluis	6.00	I
Middenkolk Groote Zeesluis, Muiden	6.50	I
Sluiskolk Oude sluis Oudesluis	6.80	II
Beurssluis	6.80	II
Biesboschsluis	6.80	II
Ottersluis	7.00	II
Roskamsluis	7.00	II
Braaksluis	7.00	II
Westfriescheslui s	7.00	II
sluiskolk sluis Leidschendam	7.00	II
sluiskolk Overlekersluis	7.00	II
Westerhavensluis, Medemblik	7.00	II
Middelharnis, sluis	7.00	II
Kleine kolk Noordersluis, Utrecht	7.00	II

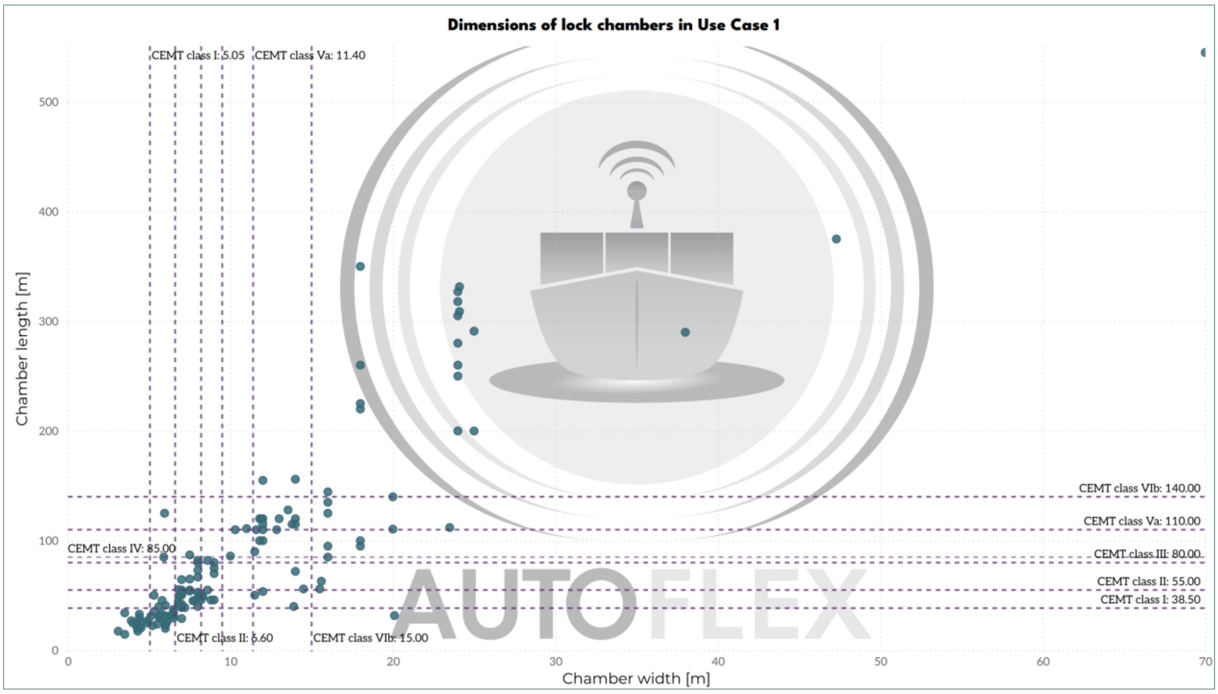

Figure 6-23: Distribution of locks in the Use Case 1 area per CEMT class

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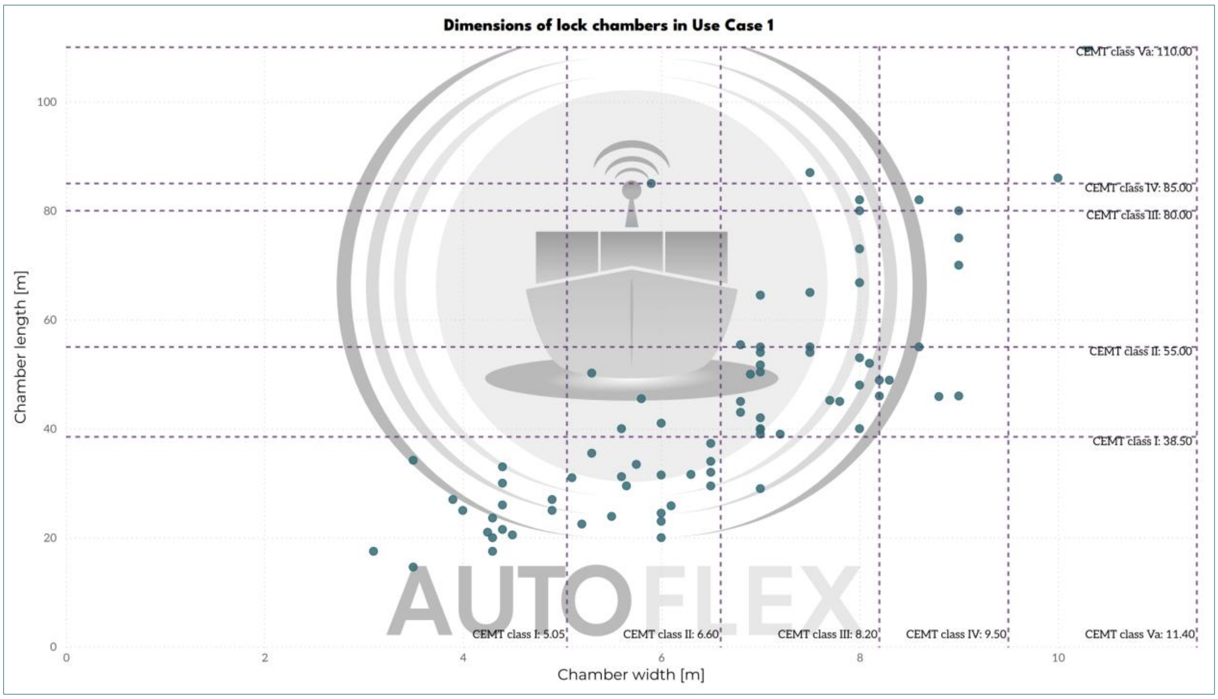

Figure 6-24: Distribution of small locks in the Use Case 1 area per CEMT class

6.4 BRIDGES AND OVERHEAD STRUCTURES

A total of 1,954 bridge openings are located in the Use Case 1 area. As has been explained above, a bridge construction may consist of different bridge elements, leading to different bridge openings and, thus, different lanes to pass the bridge. Fixed bridges oftentimes span over the entire inland waterway so that the entire bridge is a bridge opening with one (large) lane for bridge passage. As can be seen in Figure 6-25, the largest portion of bridges in the considered geographic area exhibit a single bridge opening (with 1,183 units) whereas exactly 250 bridges feature more than one bridge opening.

Being a country with a dense inland waterway network and a correspondingly large variety of bridges over water, all above-mentioned bridge types can be found throughout the Netherlands. Figure 6-26 and Figure 6-27 show maps of the spatial distribution of the bridge openings, the earlier differentiated by bridge type and the latter by movability. Although nearly two thirds of the bridge openings are fixed bridge structures, the residual third of movable bridges is well-spread over the entire Use Case 1 area, so that an accumulation is hardly detectable. With respect to bridge types, the fixed bridge and the bascule bridge represent the most prevalent type variants of each category. The rarest types are the overhead cables and overhead pipes among the fixed bridge structures, and lift bridges among the movable bridge structures (see Figure 6-28).

As expected, the bridge openings differ in size, mainly in height apart from other dimensions, as well. In general, the median height of a fixed bridge rises with the ascending CEMT class. Typically, fixed bridges over CEMT class I inland waterways are between 2.00 metres and 4.00 metres high whereas bridge openings over CEMT class II inland waterways exhibit a clearance height of 3.50 metres to 5.50 metres. In the case of a CEMT class IV waterway, the bridge height typically lies between 3.50 metres and 7.00 metres. For higher CEMT

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classes like class VI c, the bridge height significantly rises to values between 9.00 metres and 10.50 metres. Moreover, it is striking that there exist gross outliers in nearly all CEMT classes. Figure 6-29 shows the bridge heights of all fixed bridges (as the mobile ones can be opened so that the height restriction for passing inland vessels vanishes or is practically irrelevant). Since the bridge openings are represented individually, it needs to be remembered that a fixed bridge opening may be neighboured by a movable one so that either of them may allow passage to an inland vessel. Hence, the results presented henceforth need to be handled with care – as the actual route needs to be scrutinised to check the clearance heights and passability per bridge construction (and bridge opening).

As listed in Table 6-5, the lowest fixed bridges in the Use Case 1 area are exceptionally low, so that a passage of theirs is not possible (to date). Interestingly, the pertaining waterways are not accessible to inland vessels designed in the AUTOFLEX project, e. g., as the inland waterways have not been assigned to a CEMT class or further information about them is not available.

Among those bridge openings over waterways categorised in one of the CEMT classes, the situation is hardly better: the required clearance height of a bridge opening for the AUTOFLEX CEMT class II inland vessel with one container layer is 2.19 metres whereas the value amounts to 1.69 metres for the AUTOFLEX CEMT class IV inland vessel. While the earlier cannot pass any of the eleven lowest bridge openings on accessible waterways (i. e., CEMT classes II and higher), the latter fails to pass only two bridge openings on waterways of CEMT classes IV and higher (see Table 6-6 and Table 6-7). The clearance heights of both AUTOFLEX reference vessels are used for the analysis of bridge passage possibilities. As the movable bridges are attributed with operating times and waiting times, an idea could have been to sail through the bridges without operating them – possibly with max. one container layer.

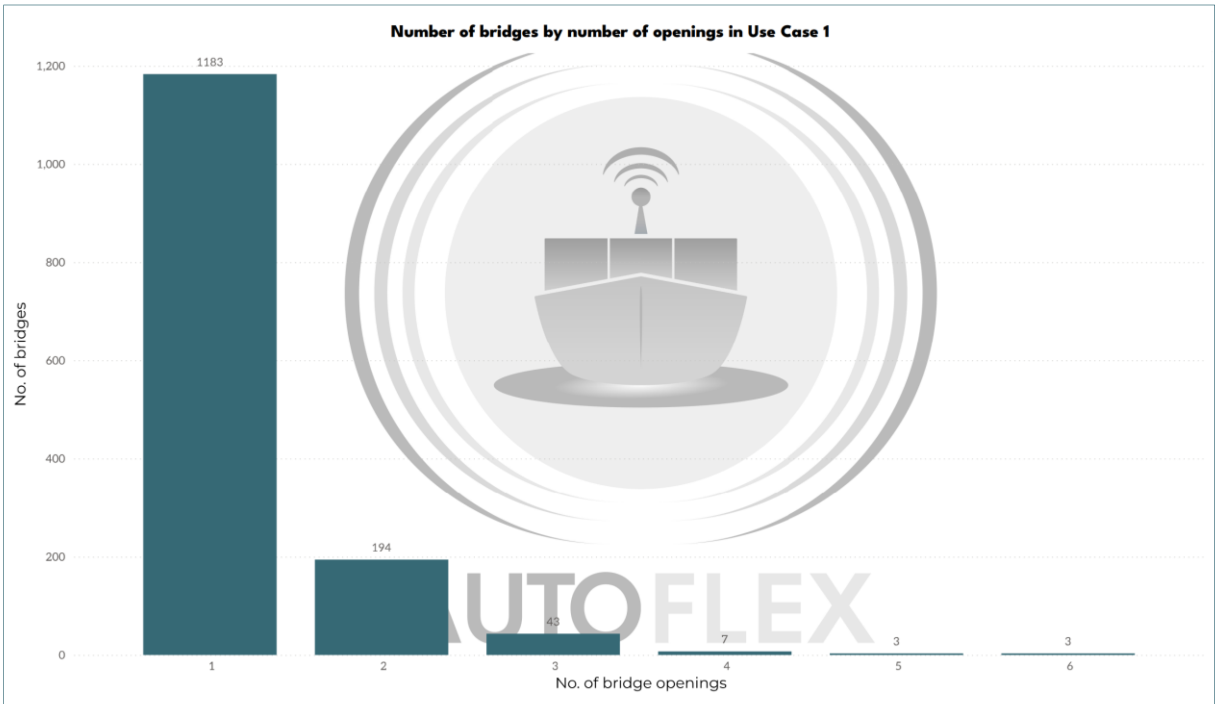

Figure 6-25: Number of bridges with one or several bridge openings in the Use Case 1 area

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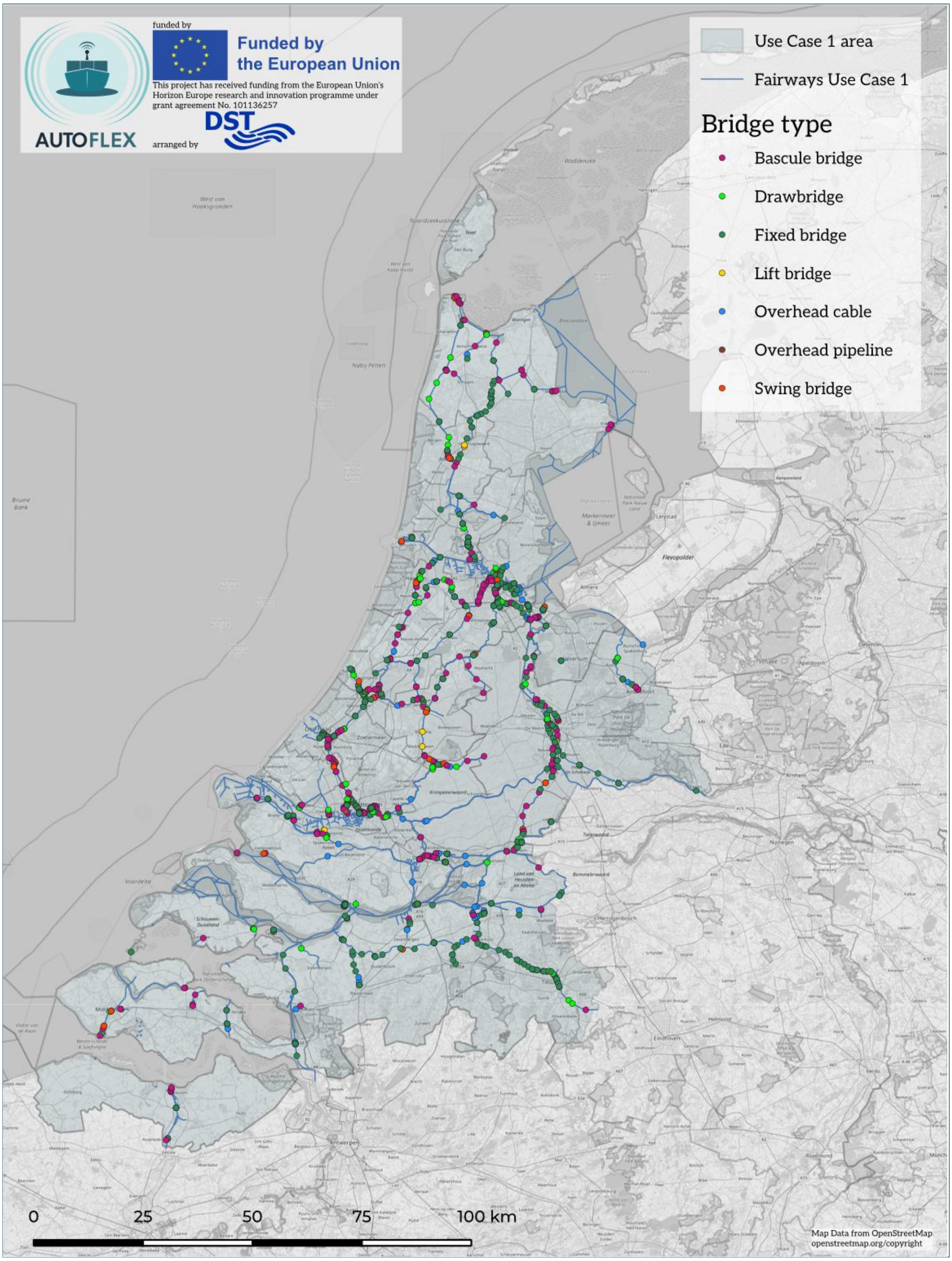

Figure 6-26: Types of bridges in the Use Case 1 area[51]

[51] Display per bridge opening

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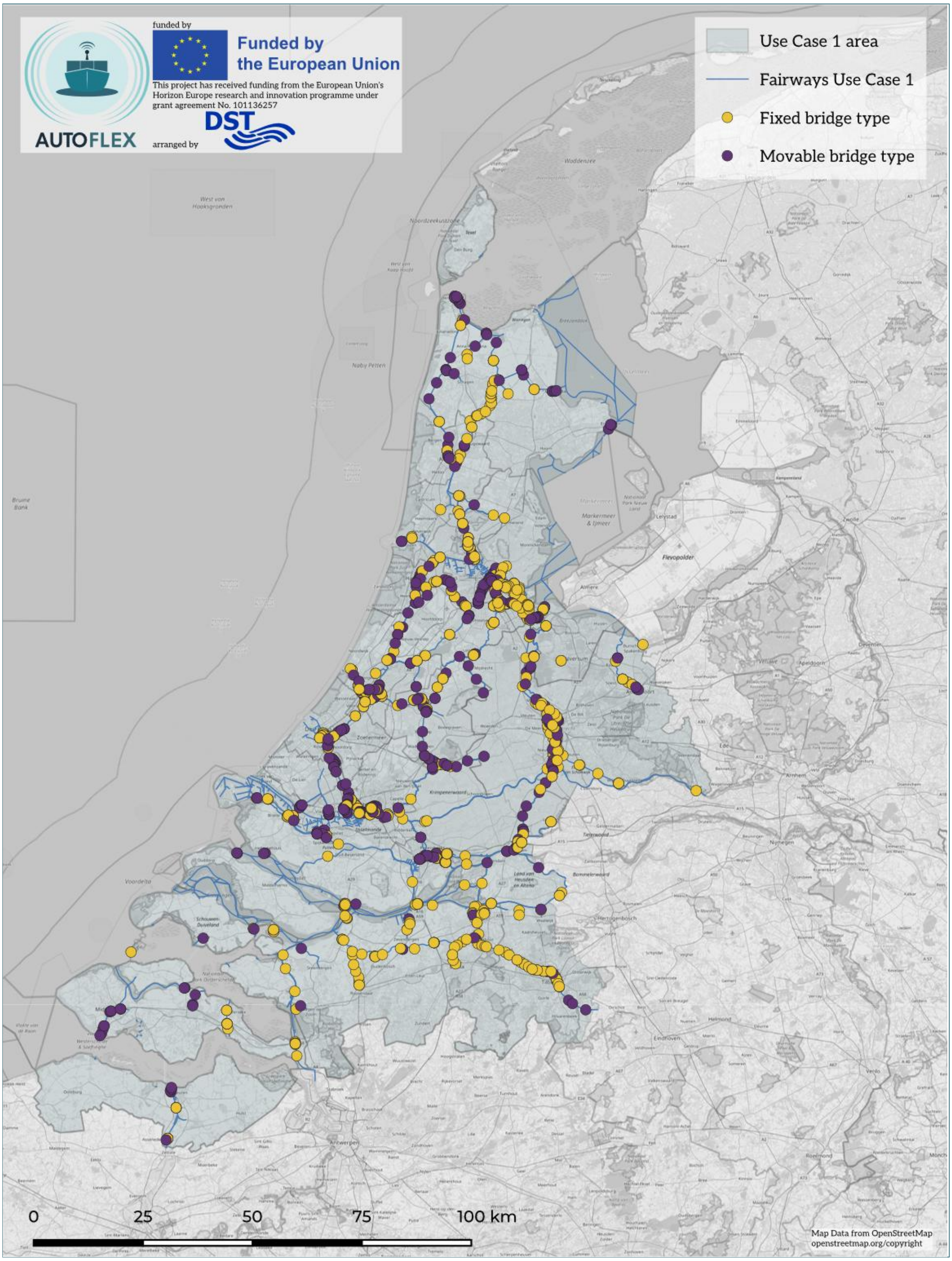

Figure 6-27: Fixed and movable bridges in the Use Case 1 area[52]

[52] Display per bridge opening

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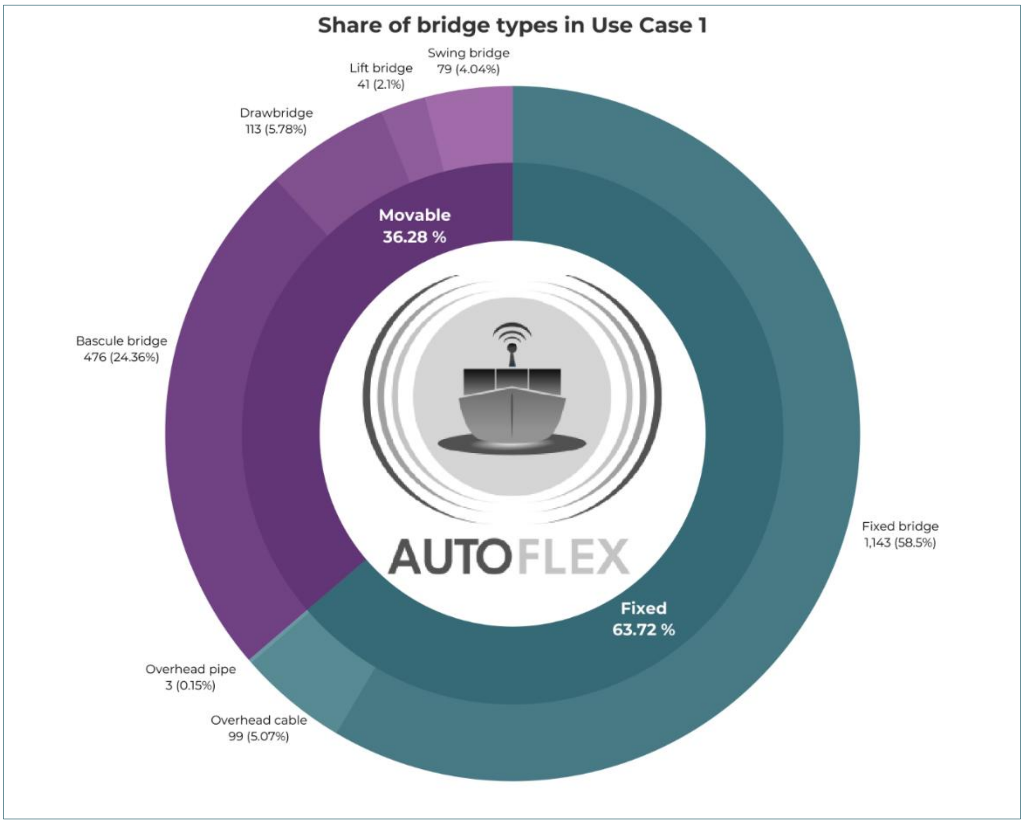

Figure 6-28: Proportion of fixed and movable bridges in the Use Case 1 area

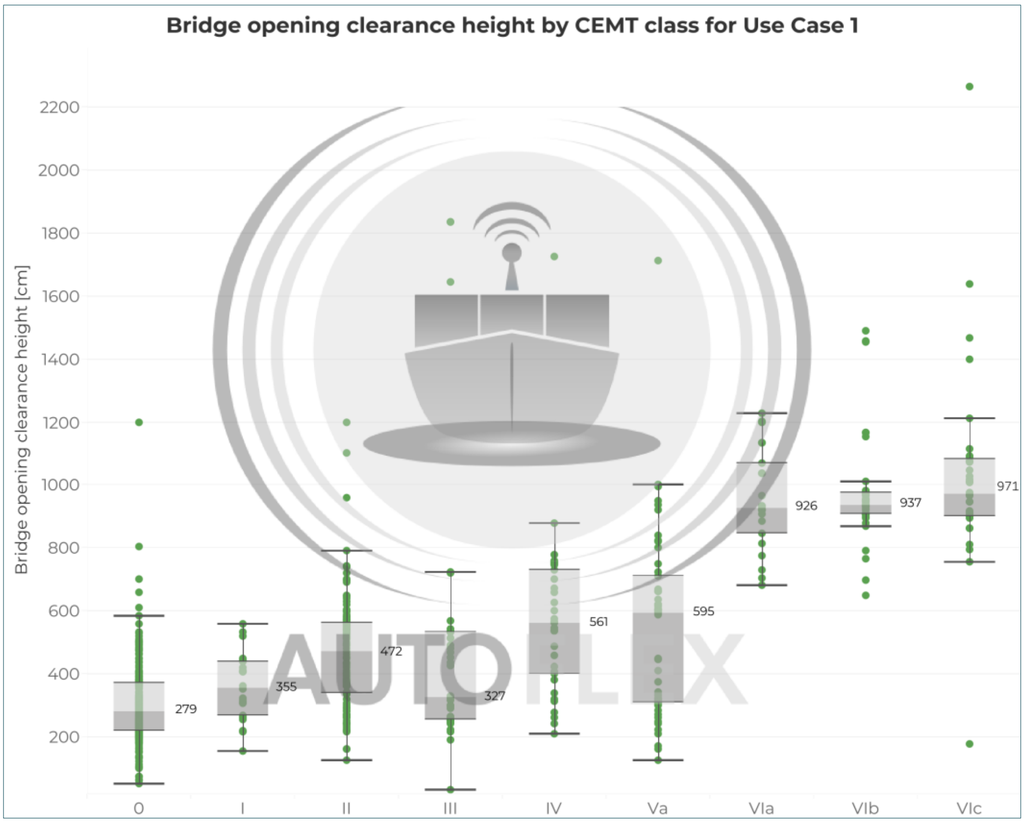

Figure 6-29: Heights of bridge openings of fixed bridges in the Use Case 1 area

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Table 6-5: Lowest bridge openings of fixed bridges in the Use Case 1 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of cont. layers (CEMT II)**	**Permissible no. of cont. layers (CEMT IV)**
Lodewijk Pincoffsbrug	0.30	impassable	impassable
Doorvaartopening (vast) Karl Popperbrug	0.50	impassable	impassable
Waver, voetbrug	0.60	impassable	impassable
Doorvaartopening (vast) Jan Brouwerbrug	0.63	impassable	impassable
Doorvaartopening (vast) Evert van der Wallbrug	0.72	impassable	impassable
Doorvaartopening (vast) Oetewalerbrug	0.75	impassable	impassable
Brug Besoijen	1.00	impassable	impassable
Doorvaartopening (vast) Kaap de Goede Hoopbrug	1.01	impassable	impassable
Doorvaartopening (vast) brug Wibautstraat overspant Ringvaart Watergra	1.01	impassable	impassable
Doorvaartopening (vast) Berta de Vriesbrug	1.06	impassable	impassable

Table 6-6: Lowest bridge openings of fixed bridges on the waterways accessible to the AUTOFLEX CEMT class II inland vessel in the Use Case 1 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of container layers (CEMT II)**
Lodewijk Pincoffsbrug	0.30	impassable
Doorvaartopening 2 (vast) Puntbrug	1.24	impassable
Doorvaartopening 2 (vast) Vice-Admiraal Moormanbrug	1.25	impassable
Doorvaartopening 1 (vast) Regentssebrug	1.60	impassable
Nelson Mandelabrug	1.60	impassable
Doorvaartopening 1 (vast) Parkhavenbrug	1.62	impassable
Doorvaartopening (beweegbaar) van Abel Tasmanbrug	1.70	impassable
Doorvaartopening 2 (vast) Rijnhavenbrug	1.78	impassable
Doorvaartopening 2 (vast) van Schrijversbrug	1.90	impassable
Doorvaartopening 2 (Vast) van Vlielandbrug	2.10	impassable
Spoorwegbassin, werkeersbrug	2.10	impassable

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Table 6-7: Lowest bridge openings of fixed bridges on the waterways accessible to the AUTOFLEX CEMT class IV inland vessel in the Use Case 1 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of container layers (CEMT IV)**
Doorvaartopening 2 (vast) Vice-Admiraal Moormanbrug	1.25	impassable
Nelson Mandelabrug	1.60	impassable
Doorvaartopening (beweegbaar) van Abel Tasmanbrug	1.70	1
Doorvaartopening 2 (vast) Rijnhavenbrug	1.78	1
Doorvaartopening 2 (Vast) van Vlielandbrug	2.10	1
Spoorwegbassin, verkeersbrug	2.10	1
Doorvaartopening 1 (Vast) van Prins Willem Alexanderbrug, Koog aan de	2.22	1
Doorvaartopening 1 (Vast) van Victoriebrug	2.40	1
Prinsenlandsebrug	2.40	1
Doorvaartopening 6 (Vast) van Prins Willem Alexanderbrug, Koog aan de	2.49	1

Figure 6-30 shows the bridge clearance of all bridge openings in the Use Case 1 area for the AUTOFLEX CEMT class II inland vessel whereas Figure 6-31, Figure 6-32, and Figure 6-33 show the same matter with movable bridges in closed state, movable bridges in open state, and fixed bridges only, respectively. It becomes evident that sailing underneath movable bridge openings is hardly possible, so that operating times will have to be incurred when operating in the considered geographic area. By operating the movable bridges, however, the height restrictions are largely lifted as only a few bridge openings remain impassable. Lifting those bridges in height or replacing them with movable bridges could result in an extension of the coverable network. Similarly, the AUTOFLEX CEMT class IV vessel cannot pass several movable bridge openings in the Use Case 1 area (see Figure 6-34, Figure 6-35, and Figure 6-36) whereas only very few fixed bridges remain a challenge (see Figure 6-37).

This means that operation will be possible for both AUTOFLEX reference vessels. When taking a look at the prospective utilisation, various waterway stretches allow single container layer transport only whereas others facilitate double-layer transport as well. This applies to both AUTOFLEX reference vessels in a similar way. On the outer ring, even triple-layer transport is possible (with the AUTOFLEX CEMT class IV inland vessel).

Generally, the AUTOFLEX CEMT class II inland vessel is capable of passing the vast majority of bridges (over all CEMT classes) where the share of impassable bridges varies between the different CEMT classes (see Figure 6-38). In the case of the AUTOFLEX CEMT class IV inland vessel, the number of impassable bridges is even lower (see Figure 6-39). One major explanation for this phenomenon lies in the navigability of larger waterways with significantly higher bridges.

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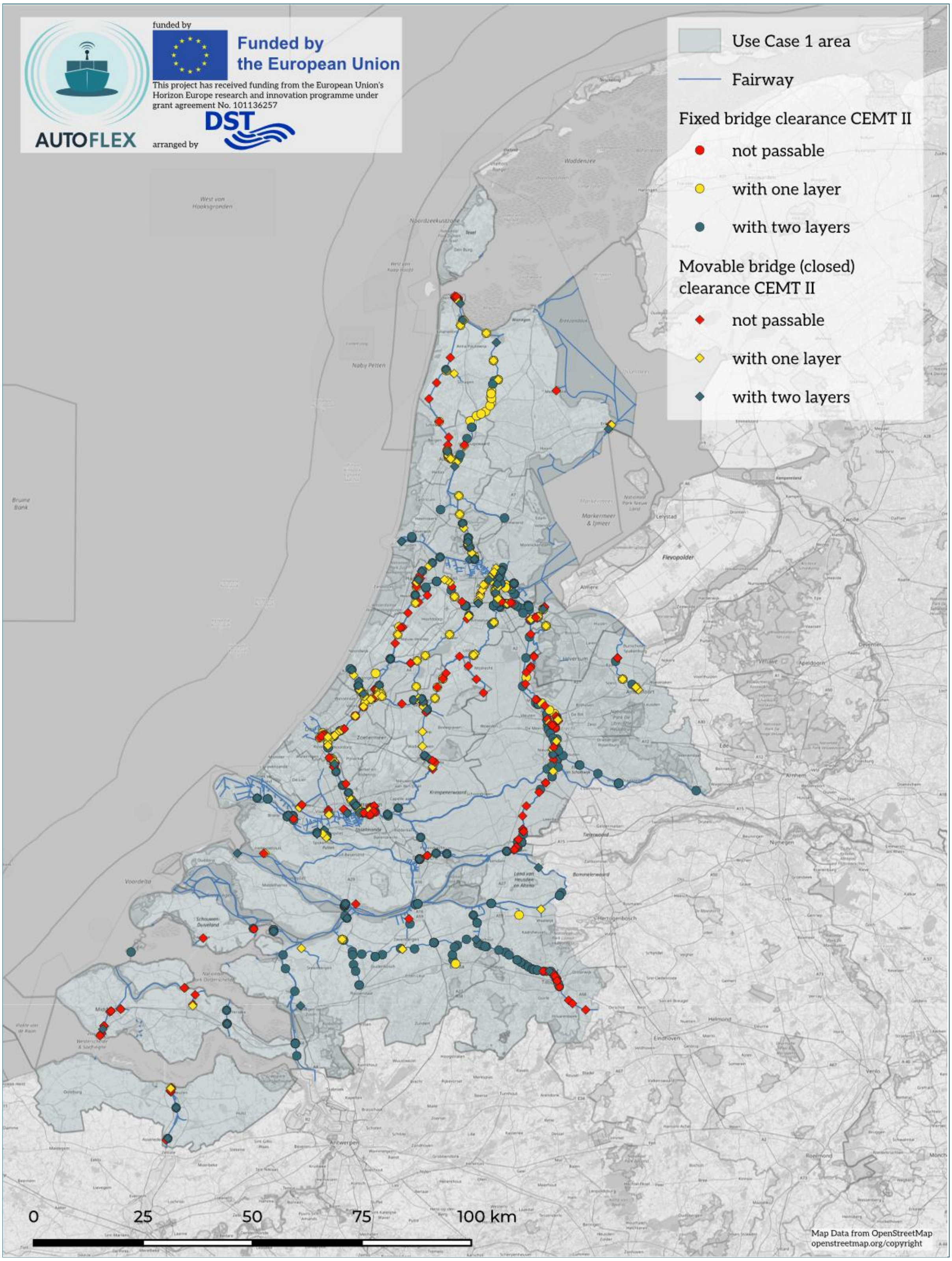

Figure 6-30: Clearance heights of all bridges on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class II vessel)[53]

[53] Display per bridge opening; movable bridges are assumed as unoperated (closed)

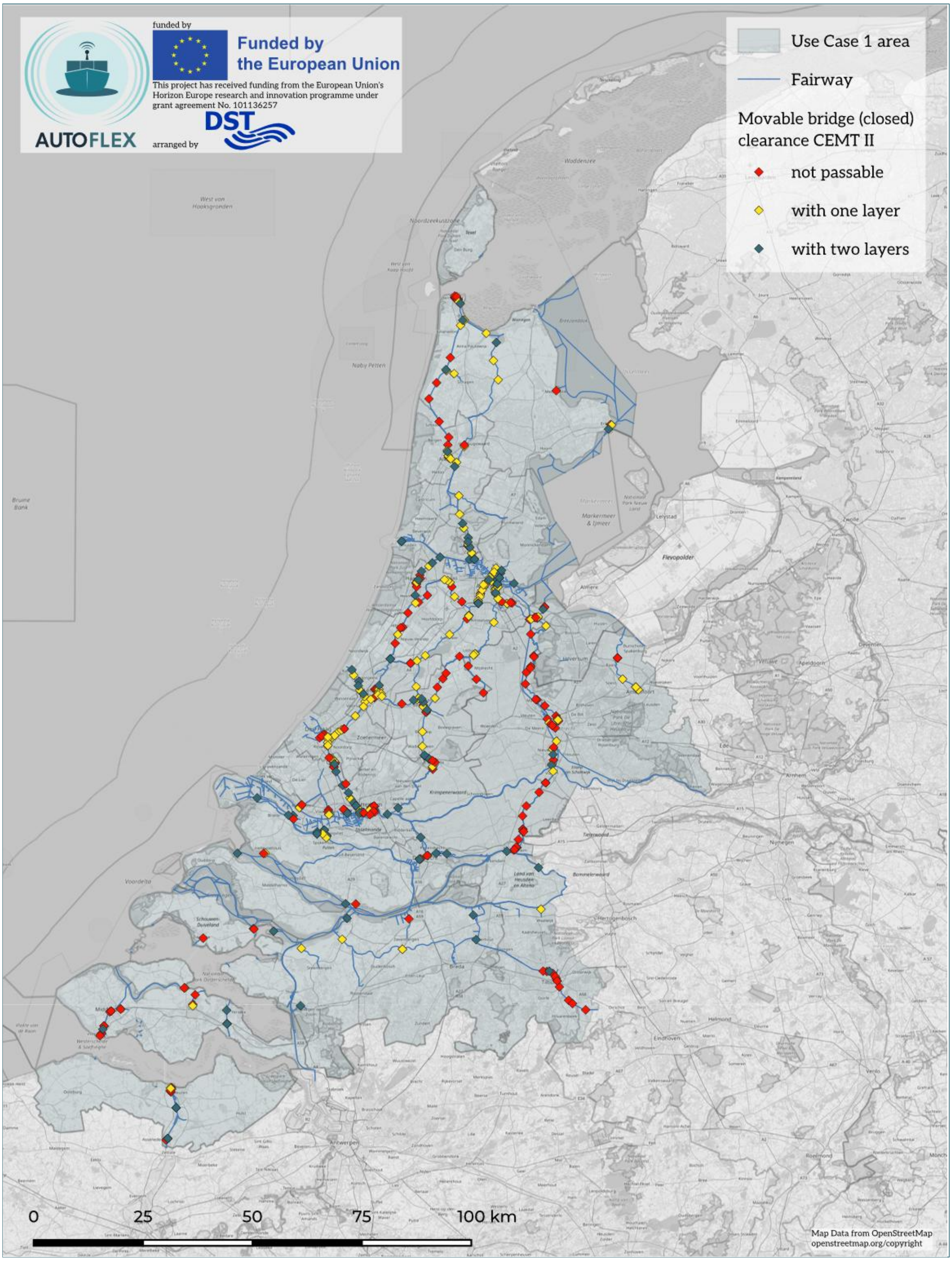

Figure 6-31: Clearance heights of the movable bridges (in closed state) on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class II vessel)[54]

[54] Display per bridge opening; movable bridges are assumed as unoperated (closed)

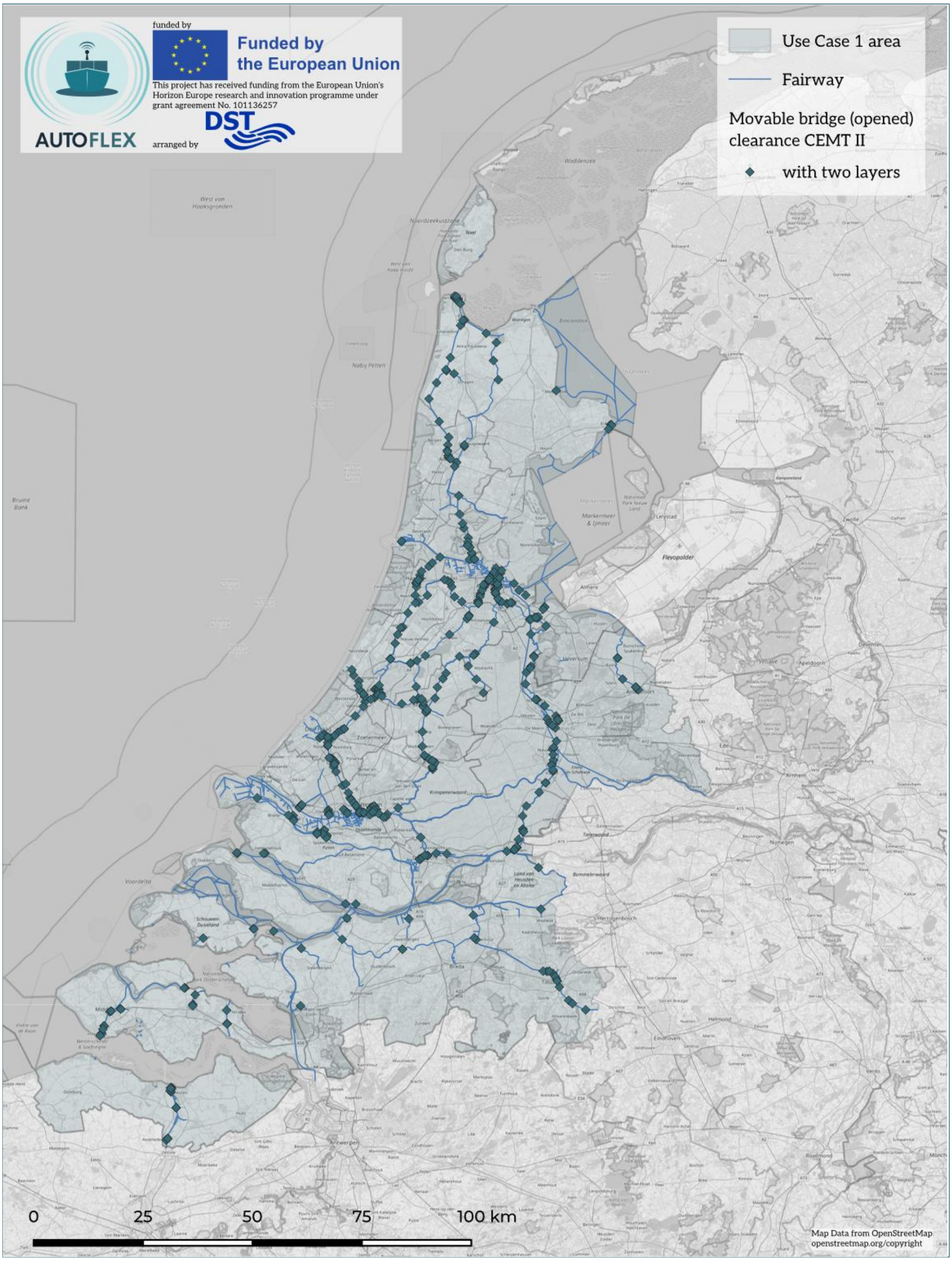

Figure 6-32: Clearance heights of the movable bridges (in opened state) on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class II vessel)[55]

[55] Display per bridge opening; movable bridges are assumed as unoperated (closed)

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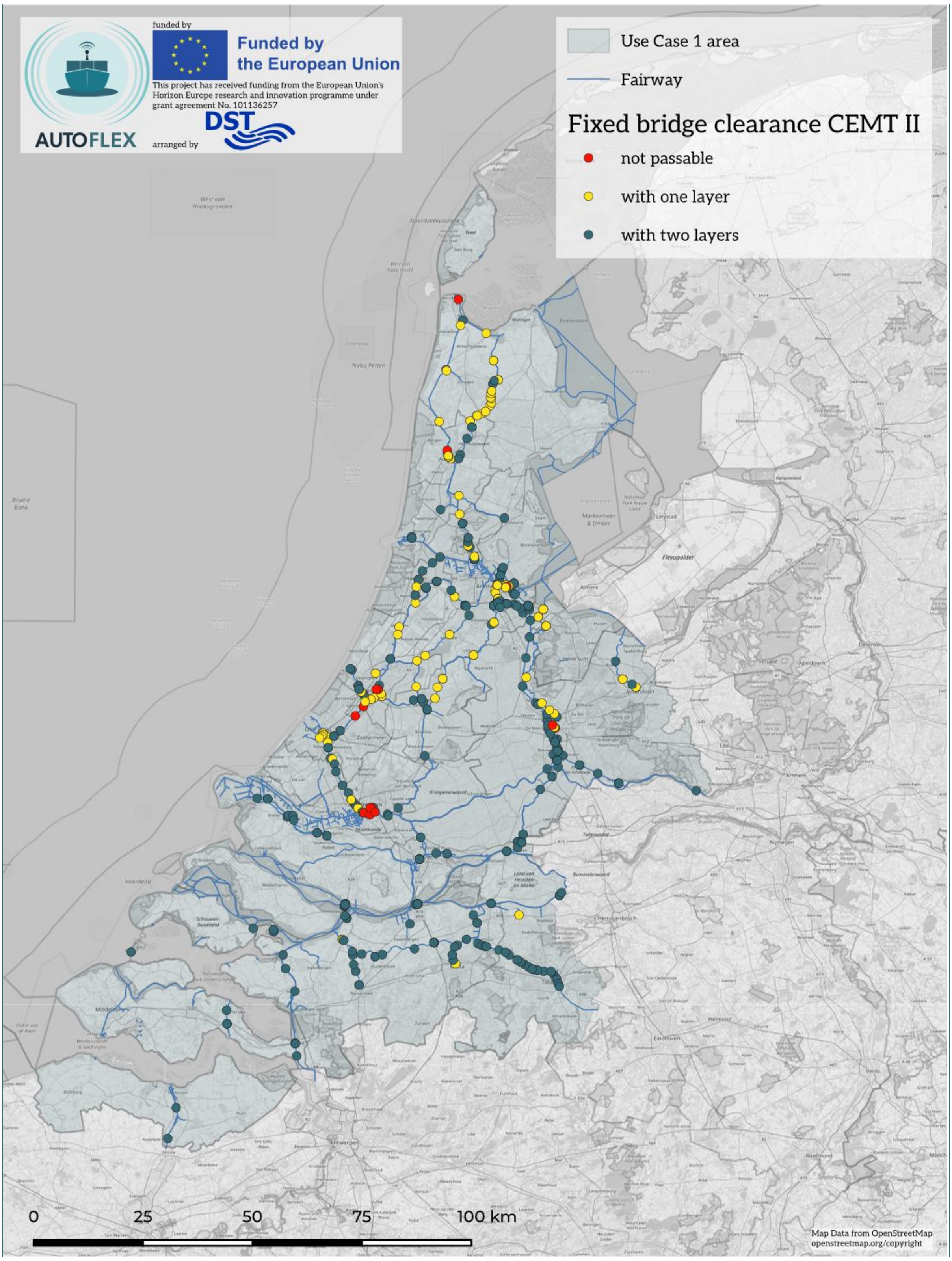

Figure 6-33: Clearance heights of the fixed bridges on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class II vessel)[56]

[56] Display per bridge opening

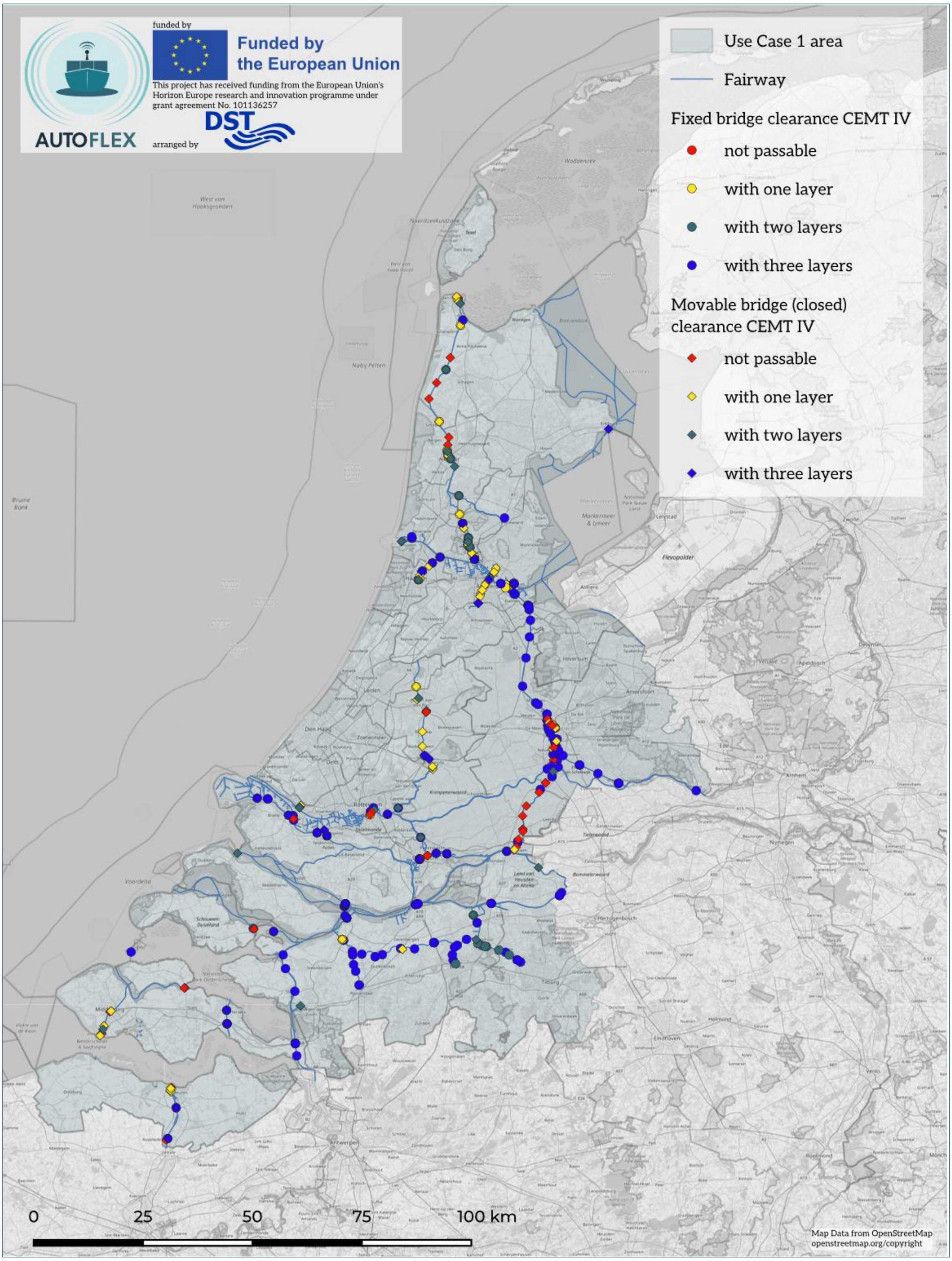

Figure 6-34: Clearance heights of all bridges on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class IV vessel)[57]

[57] Display per bridge opening; movable bridges are assumed as unoperated (closed)

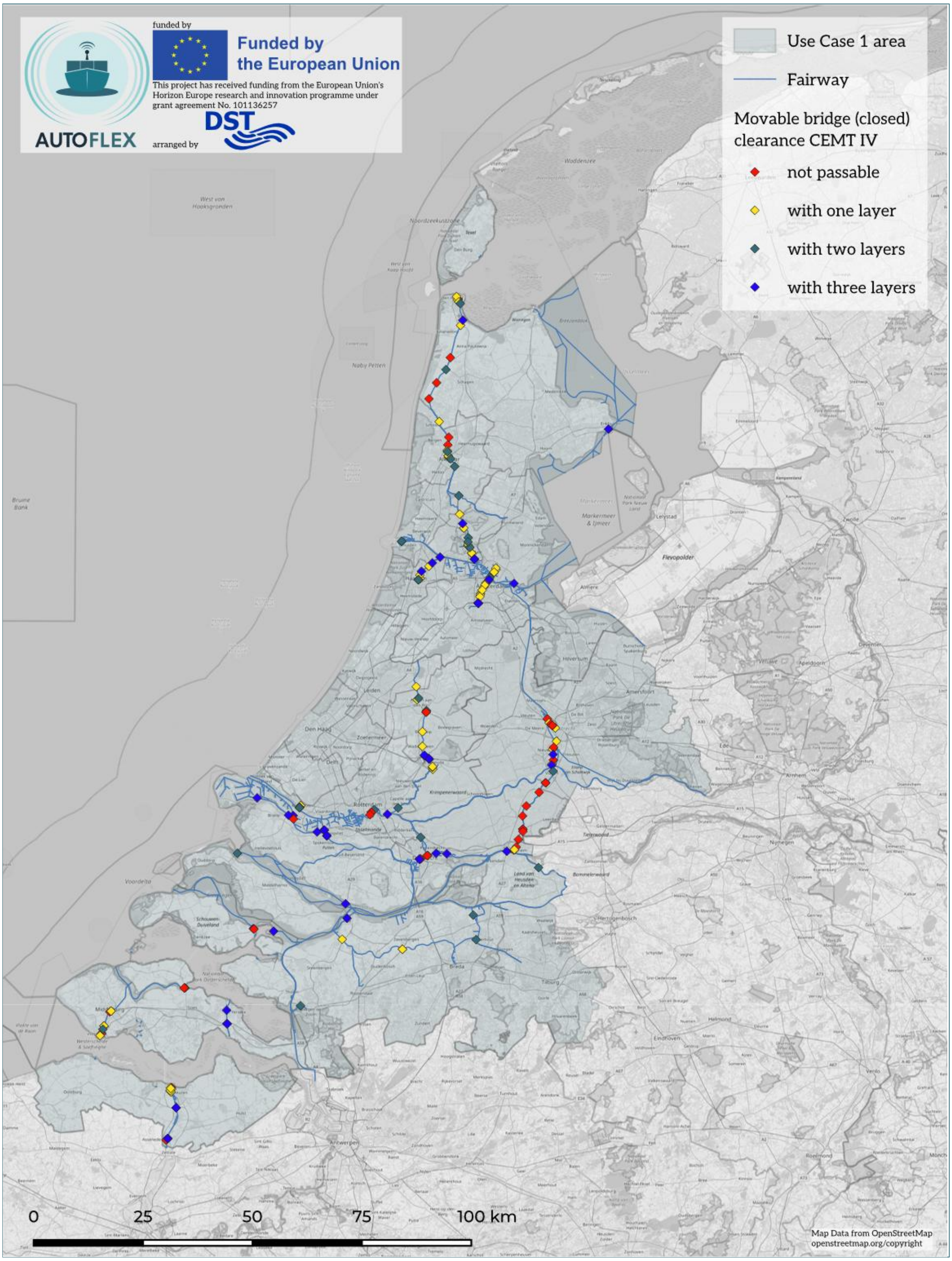

Figure 6-35: Clearance heights of the movable bridges (in closed state) on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class IV vessel)[58]

[58] Display per bridge opening; movable bridges are assumed as unoperated (closed)

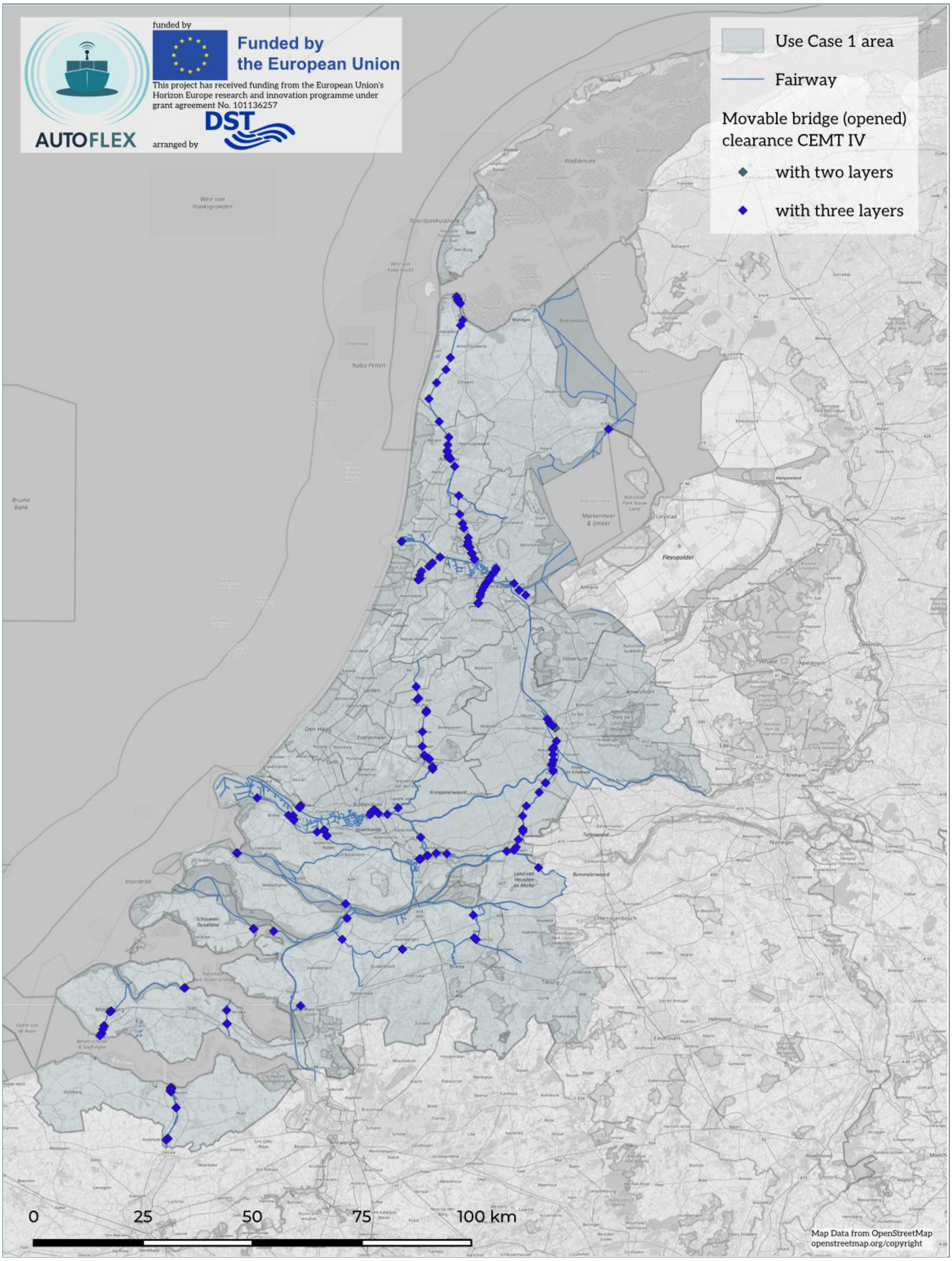

Figure 6-36: Clearance heights of the movable bridges (in opened state) on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class IV vessel)[59]

[59] Display per bridge opening; movable bridges are assumed as unoperated (closed)

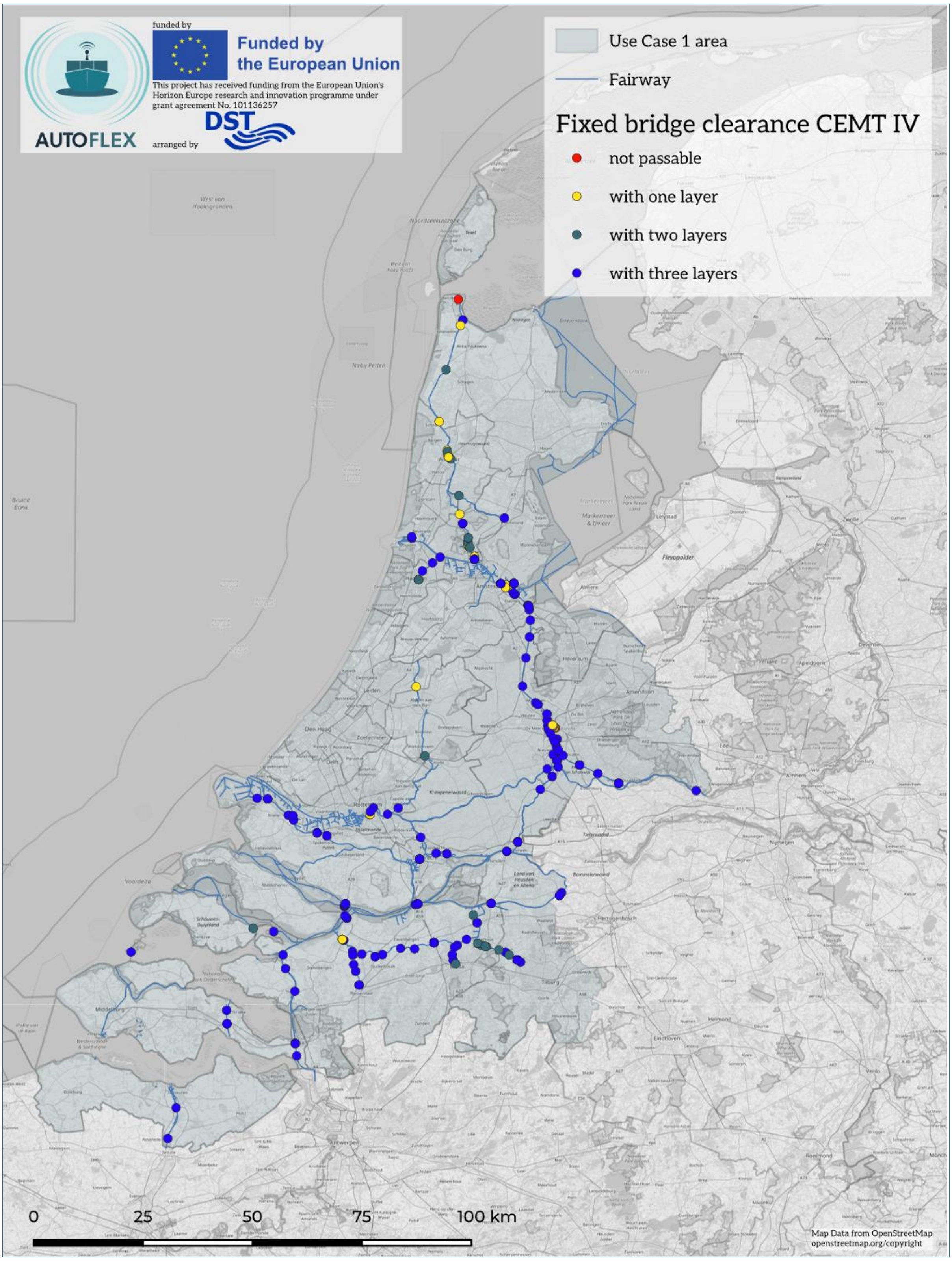

Figure 6-37: Clearance heights of the fixed bridges on the inland waterways in Use Case 1 area (for the AUTOFLEX CEMT class IV vessel)[60]

[60] Display per bridge opening

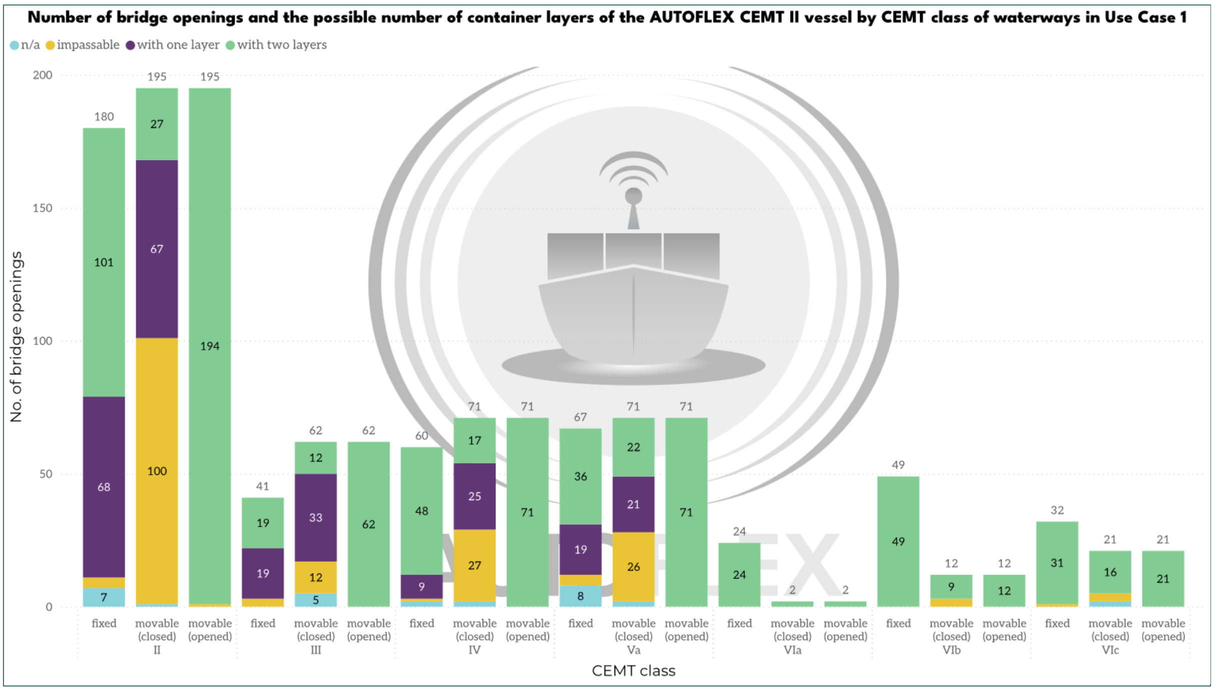

Figure 6-38: Number of bridge openings of fixed and movable bridges per CEMT class (passable for the AUTOFLEX CEMT II inland vessel)

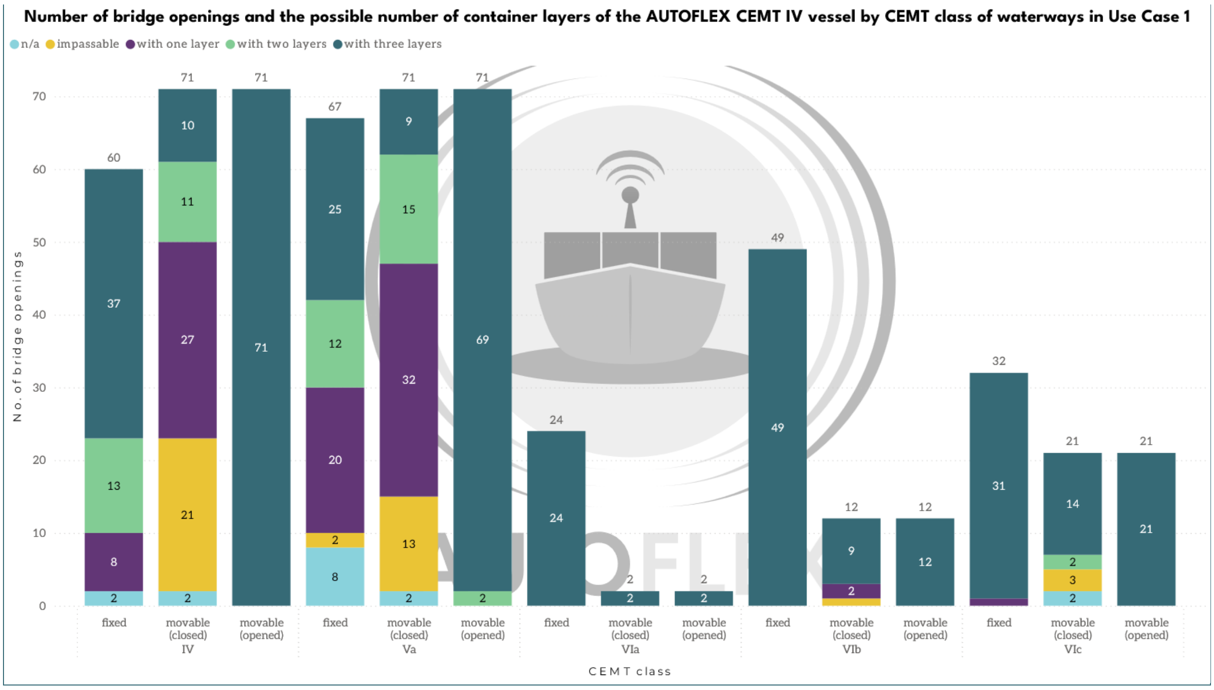

Figure 6-39: Number of bridge openings of fixed and movable bridges per CEMT class (passable for the AUTOFLEX CEMT IV inland vessel)

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7 POINTS OF INTEREST IN USE CASE 2

7.1 INLAND WATERWAYS

The inland waterway network of the Use Case 2 area is situated in the north and centre of Belgium as well as in the southwest of the Netherlands. It borders directly on the Use Case 1 area and includes the Belgian metropolitan areas of Antwerp, Brussels, and Ghent. The area encompasses multiple inland waterways, such as the Albert Canal, the Brussels-Scheldt Canal, the Dendre river, the Leie river, the Scheldt, and the Terneuzen-Ghent Canal – as well as numerous smaller and shorter inland waterways. With Port of Antwerp-Bruges in Antwerp and North Sea Port[61] in Ghent and Terneuzen, two large European seaports as well as a number of Belgian inland ports are also located on the considered geographic area. In general, the region is characterized by a high traffic density – apart from the inland waterways, numerous roads and highways and railways run through the region.

Every larger region of the country is well connected to the inland waterway network so that potential consignors can exploit (and benefit from) a sufficient network density – both for seaport hinterland traffic and continental transports. In general, a few horizontal corridors (running in east-west direction) are crossed by numerous vertical axes (running in north-south direction). Correspondingly, the same applies to the Use Case 2 area with the above-mentioned metropolitan areas. The total length of inland waterway network in the Use Case 2 area amounts to 638 kilometres, of which 289 kilometres, equalling 45.32 percent, belong to the CEMT classes I to IV. Belgium and particularly the region of Flanders features a dense network of inland waterway which spans over the entire territory, from the North Sea coast in the west to the borders to Germany and the Netherlands in the east as well as from the north (i. e., the Netherlands) to the south (including the region of Wallonia as well as France). Figure 7-1 shows the inland waterways of the Use Case 2 area.

When analysing the CEMT classes in the considered geographic area, a few inland waterway classes are missing on the map, such as the CEMT classes III and V whereas the very small inland waterways (CEMT classes I and II) as well as the large ones (CEMT classes VI and VII) are well-represented in the area. In addition, a few CEMT class IV waterways form the connectors between the different axes. Figure 7-2 presents the CEMT classes of the inland waterways in the Use Case 2 area.

Most of the inland waterways of the Use Case 2 area belong to CEMT class VI b (with 121 waterways), followed by CEMT class V a (with 63 waterways) and CEMT class VII (with 61 waterways). So, the smaller inland waterways are in the minority when it comes to the sheer number. 40 inland waterways of CEMT class IV, 38 of CEMT class II, and 29 of CEMT class I form this minority group. With respect to the total length, the largest part of the inland waterway network is assigned to CEMT class VI b (with 151 kilometres), followed by CEMT classes V a (with 124 kilometres), IV (with 110 kilometres), and I (with 108 kilometres). Figure 7-3 presents the number of waterways per CEMT class while Figure 7-4 illustrates the total length of the waterways of each CEMT class.

[61] North Sea Ports is a merger of the ports Dutch ports of Vlissingen and Terneuzen with the Flemish port of Ghent. Vlissingen is located on the other side of the Scheldt river and, thus, not part of the Use Case 2 area.

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The average length of a waterway in the Use Case 2 area amounts to nearly 1 751 kilometres whereas the median length is only 0.984 kilometres which indicates the dominance of one or a few inland waterways with extraordinarily long distances and multiple inland waterways of shorter distance. In the case of smaller inland waterways (of CEMT classes I and II) and medium-size waterways (of CEMT class IV), both the average length and the median length lie considerably above the total values (across all CEMT classes). The difference is lower for larger waterway classes, such as CEMT classes V b, VI b, and VII. The median and average lengths of all CEMT classes is listed in Table 7-1.

In general, the length values are rather small which may indicate a good density within the region. Smaller waterways may be smaller in number but (relatively) bigger in total length. Addressing this segment of the network impacts the business service concept. Whereas larger inland vessels may operate uneconomical due to nautical inaccessibility and, thus, missing business potential and lacking utilization, smaller inland vessels with lower costs due to different modes of operation (including automation and extended operation times) may profit from the small waterway stretches as they are able to provide services to areas formerly inaccessible to inland waterway transport business. Again, the AUTOFLEX reference vessels form a good base to assess the business potential.

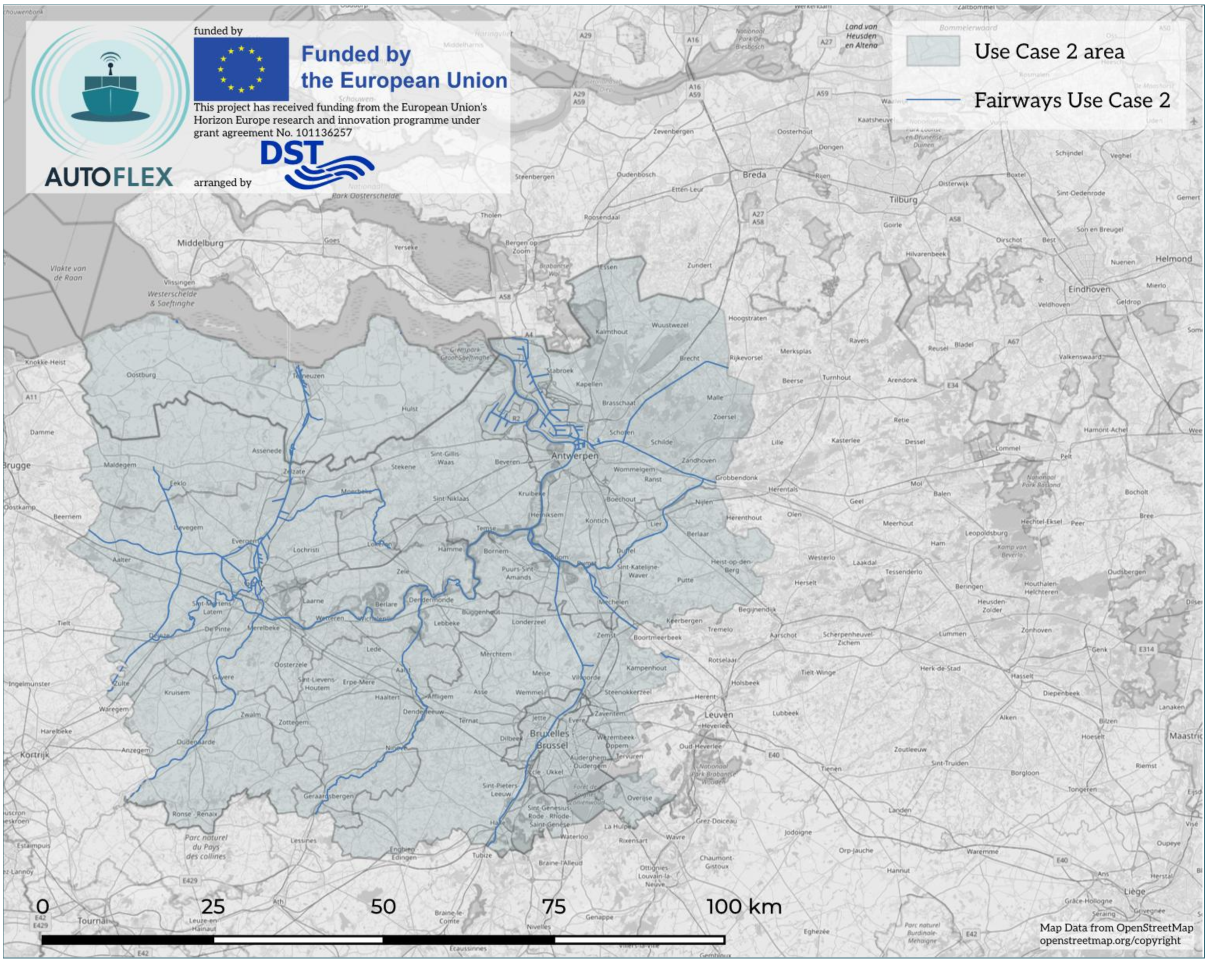

Figure 7-1: Inland waterways in the Use Case 2 area

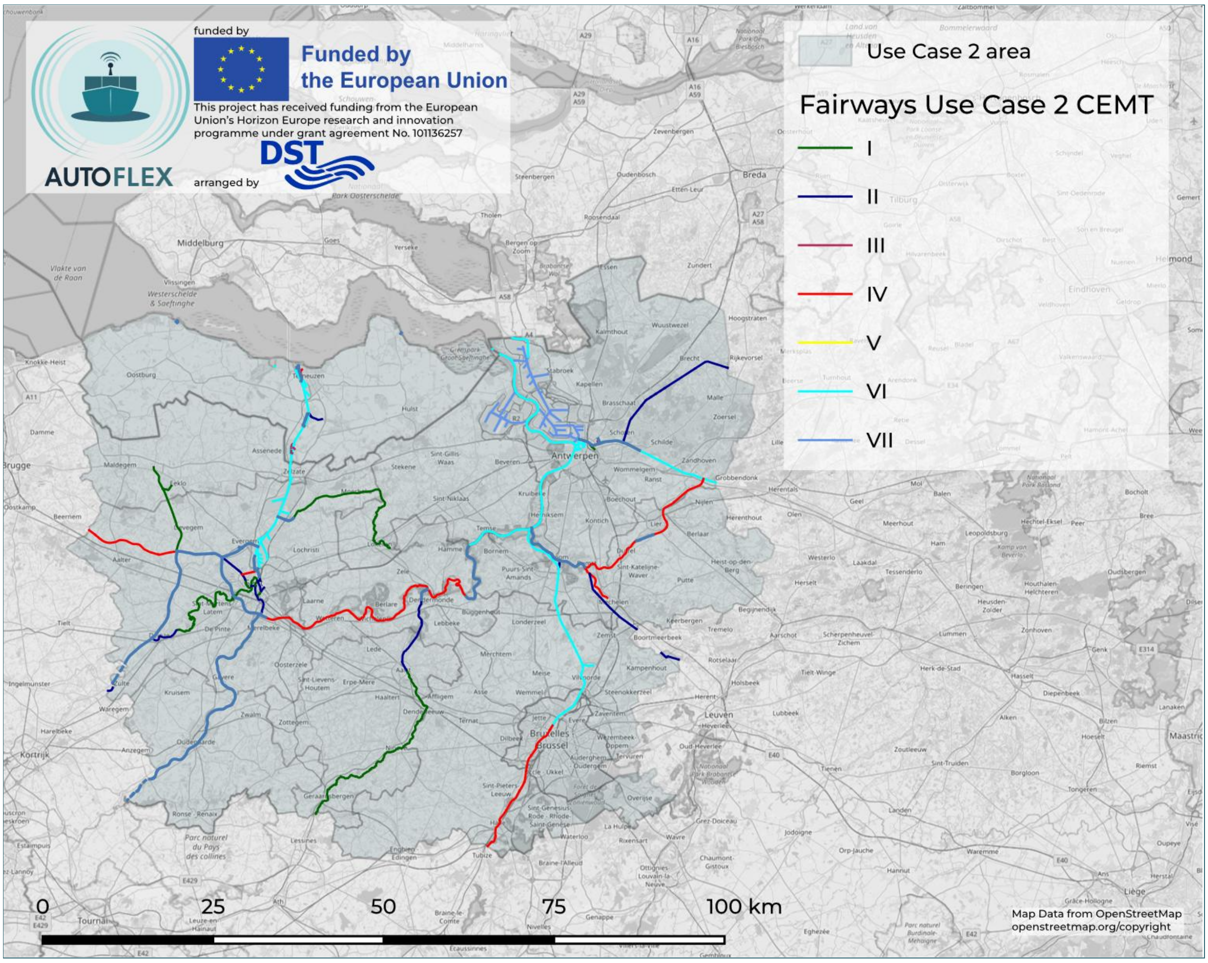

Figure 7-2: CEMT classes of inland waterways in the Use Case 2 area

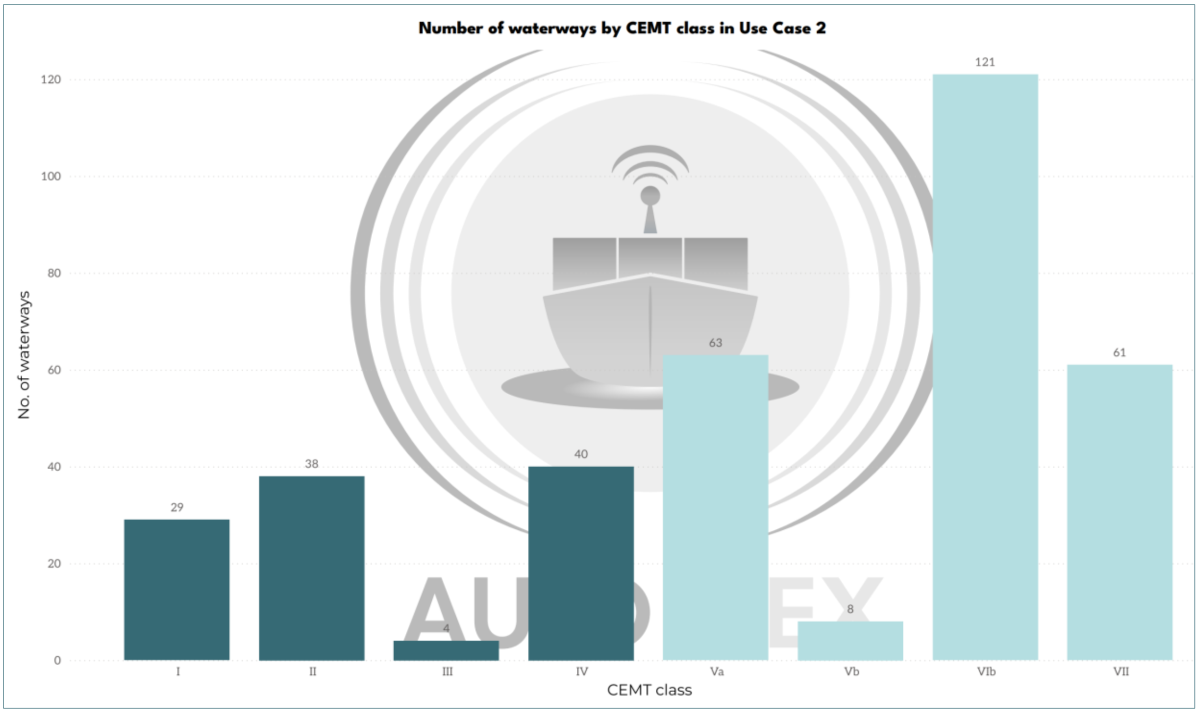

Figure 7-3: Number of inland waterways in the Use Case 2 area per CEMT class

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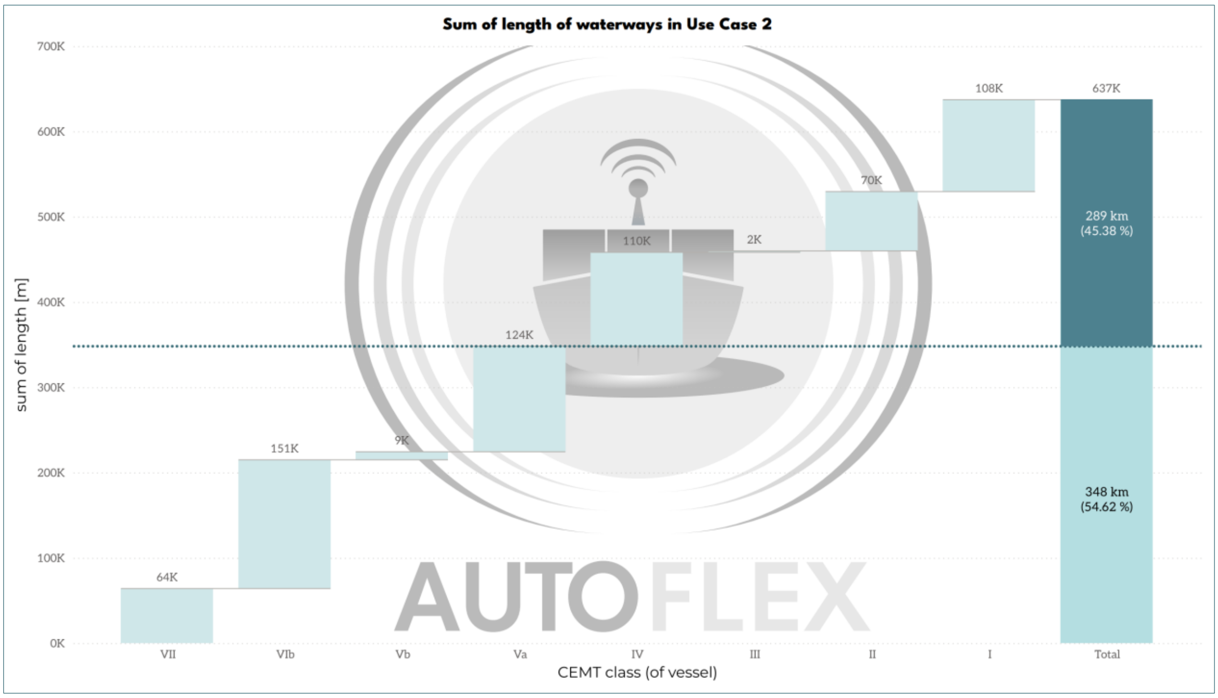

Figure 7-4: Total length of inland waterways in the Use Case 2 area per CEMT class

Table 7-1: Average and median lengths of inland waterways in the Use Case 2 area per CEMT class

CEMT class	**median length** [m]	**average length** [m]
I	1,977	3,717.45
II	1,045	1,829.84
II	383	406
IV	1,876	2,755.45
V a	927	1,963.03
V b	812	1,183.13
VI b	865	1,247.13
VII	858	1,050.13
Total	**984**	**1,750.77**

The network coverage of the AUTOFLEX inland vessels of the CEMT classes I to IV form a good base for assessment of the business potential. Similar to the examination in the Use Case 1 area, the inland waterways of the Use Case 2 area are examined from the perspective of inland vessels of different sizes (and their skippers, respectively).

From the perspective of a CEMT class V vessel, the two main north-south axes are accessible: from Terneuzen to Ghent and further southwards to the region of Wallonia and from Antwerp to Brussels. In addition, Albert Canal running eastwards from the port of Antwerp is navigable. Figure 7-5 shows the network accessible to a CEMT class V vessel.

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By switching to a CEMT class IV vessel, a horizontal axis from Bruges in the west (outside the use case area) to the confluence with the Albert Canal in the east is accessible. Thereby, the two axes are connected and operators can move from one north-south axis to another. The pertaining map is presented in Figure 7-6.

The network extension by the use of a CEMT class III vessel instead is hardly measurable. Given the little total length of CEMT class III waterways with merely two kilometres, the change in the network coverage is marginal (see Figure 7-7).

The picture is significantly different in case of using a CEMT class II vessel as several shorter stretches become accessible and several cities and municipalities not accessible to the aforementioned inland vessels become part of the inland waterway network. Figure 7-8 shows the corresponding extension.

Changing to a CEMT class I vessel has the very same effect as multiple waterways stretches to cities and regions formerly inaccessible to the larger inland vessels have become part of the network (see Figure 7-9). Additional connections to the southwest, the southeast, and the east enter the map as well as many short distances facilitating waterway transport routes between two cities in the region.

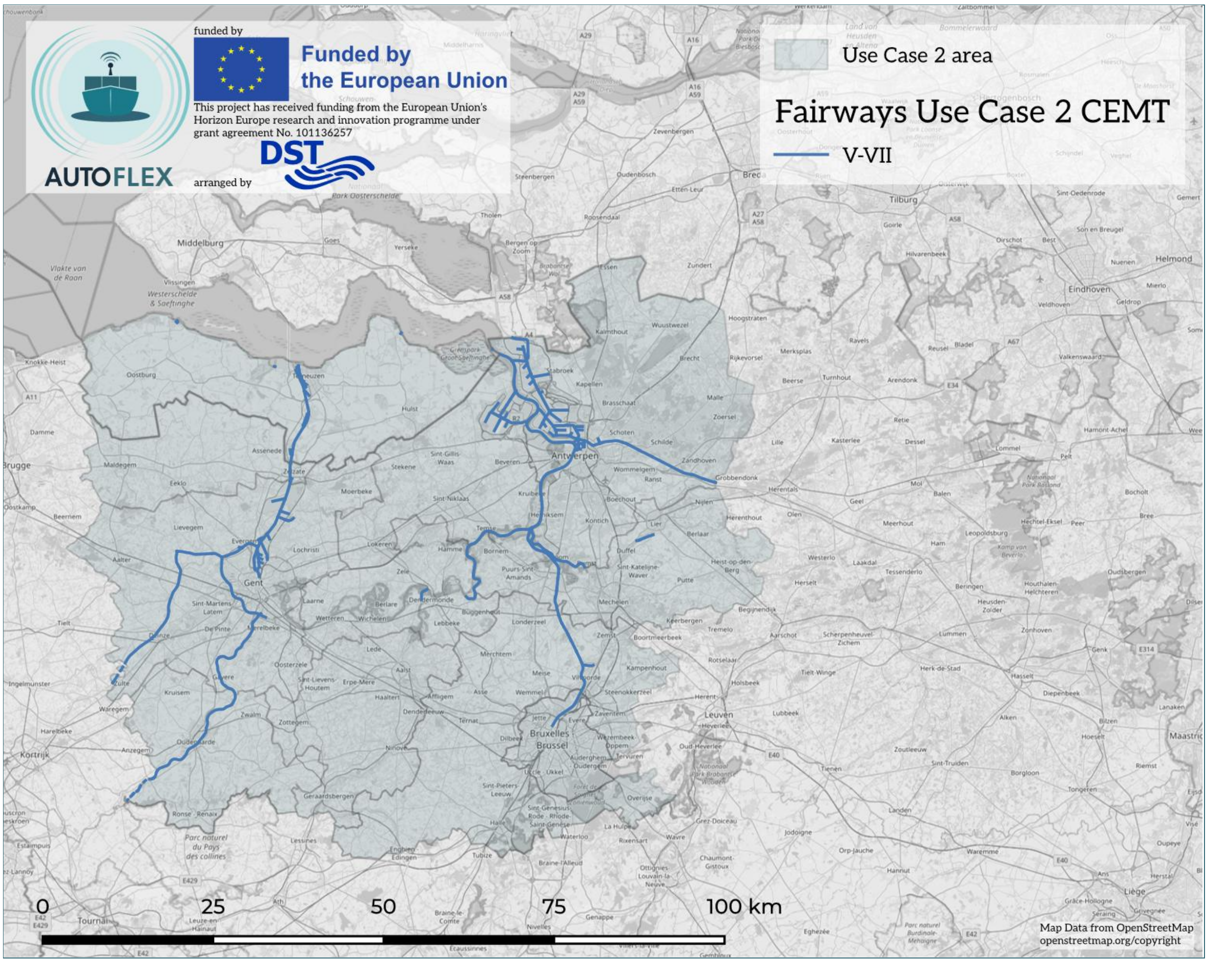

Figure 7-5: Inland waterways in the Use Case 2 area accessible for a class V vessel

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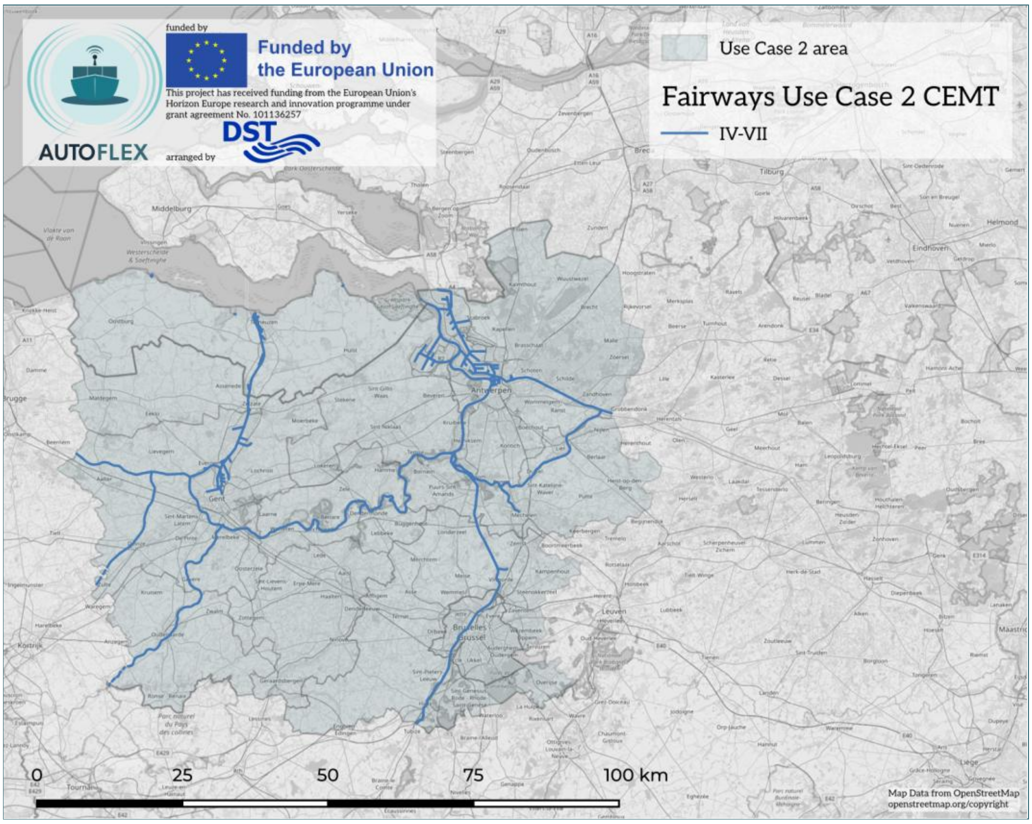

Figure 7-6: Inland waterways in the Use Case 2 area accessible for a class IV vessel

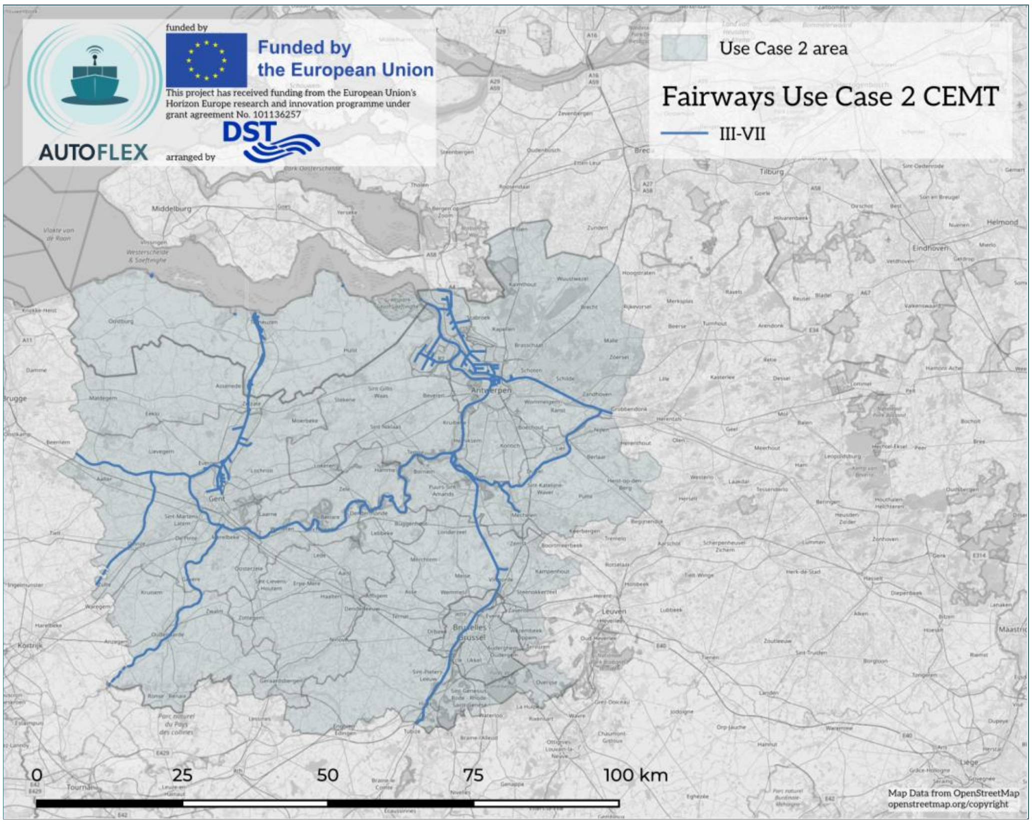

Figure 7-7: Inland waterways in the Use Case 2 area accessible for a class III vessel

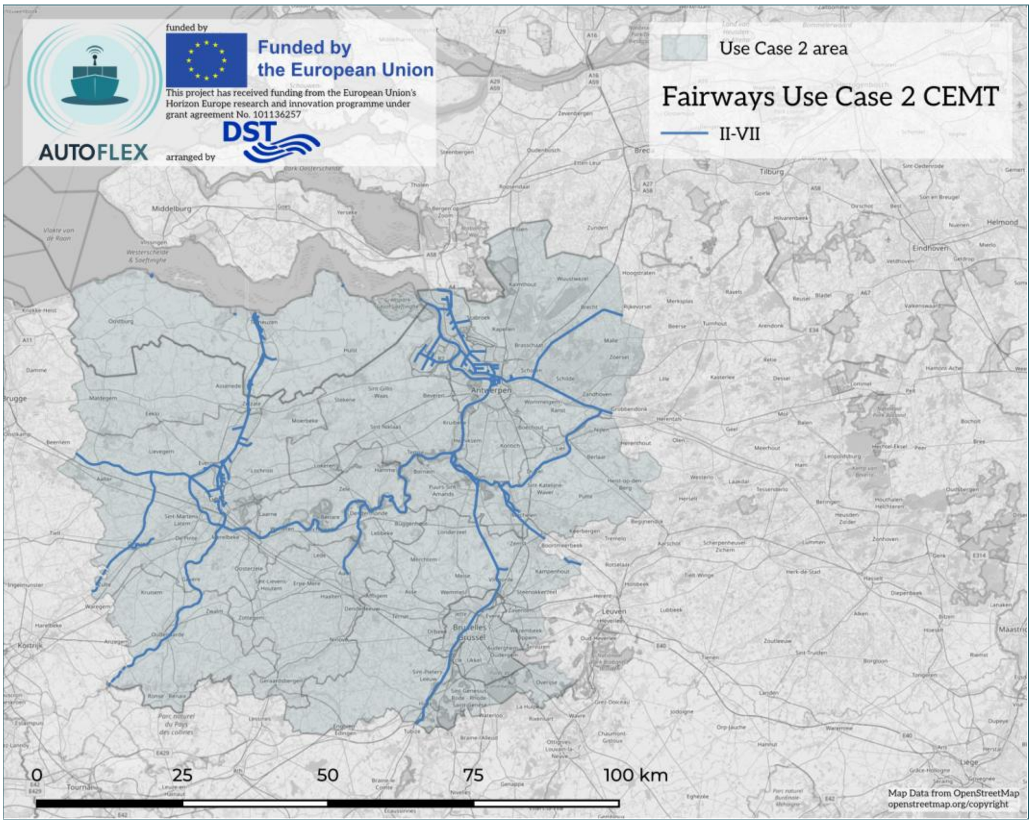

Figure 7-8: Inland waterways in the Use Case 2 area accessible for a class II vessel

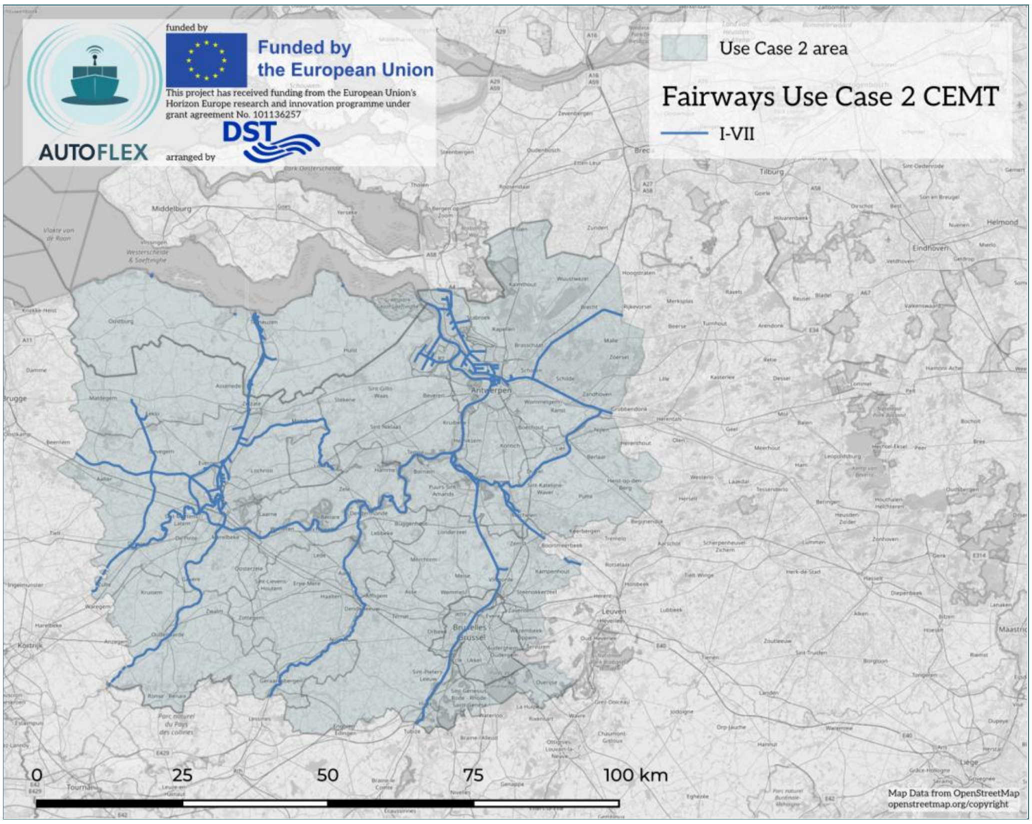

Figure 7-9: Inland waterways in the Use Case 2 area accessible for a class I vessel

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The speed limits on the inland waterway network of the Use Case 2 area confirm the above-mentioned clear distinction between larger and smaller inland waterways. While the larger waterways running from the northern part of the use case area to the centre as well as the horizontal axis connecting the two permit larger speeds, the residual waterways and waterway stretches feature more restrictive speed limit with speeds between three and eleven kilometres per hour. Figure 7-10 shows the speed limits on all inland waterways in the Use Case 2 area.

Concerning the tidal influence, all inland waterways are protected from the phenomenon except the Scheldt river (i. e., the Zeeschlede and its extensions Beneden-Zeeschlede and Boven-Zeeschlede) – running through the port of Antwerp both towards the south and southwest to the port of Ghent and towards the southwest halfway to the Albert Canal. A closer look at the CEMT classes subject to tidal influence that this largely applies to the large CEMT classes VII, VI b, V a – and IV. So, the tide-dependency is highly relevant to the AUTOFLEX inland vessels of the CEMT classes I to IV as they can operate on all the waterways impacted by the tide. Figure 7-11 shows the tide-dependency of the inland waterways as a map while Figure 7-12 shows the composition of tide-dependent and tide-independent inland waterways of the Use Case 2 area.

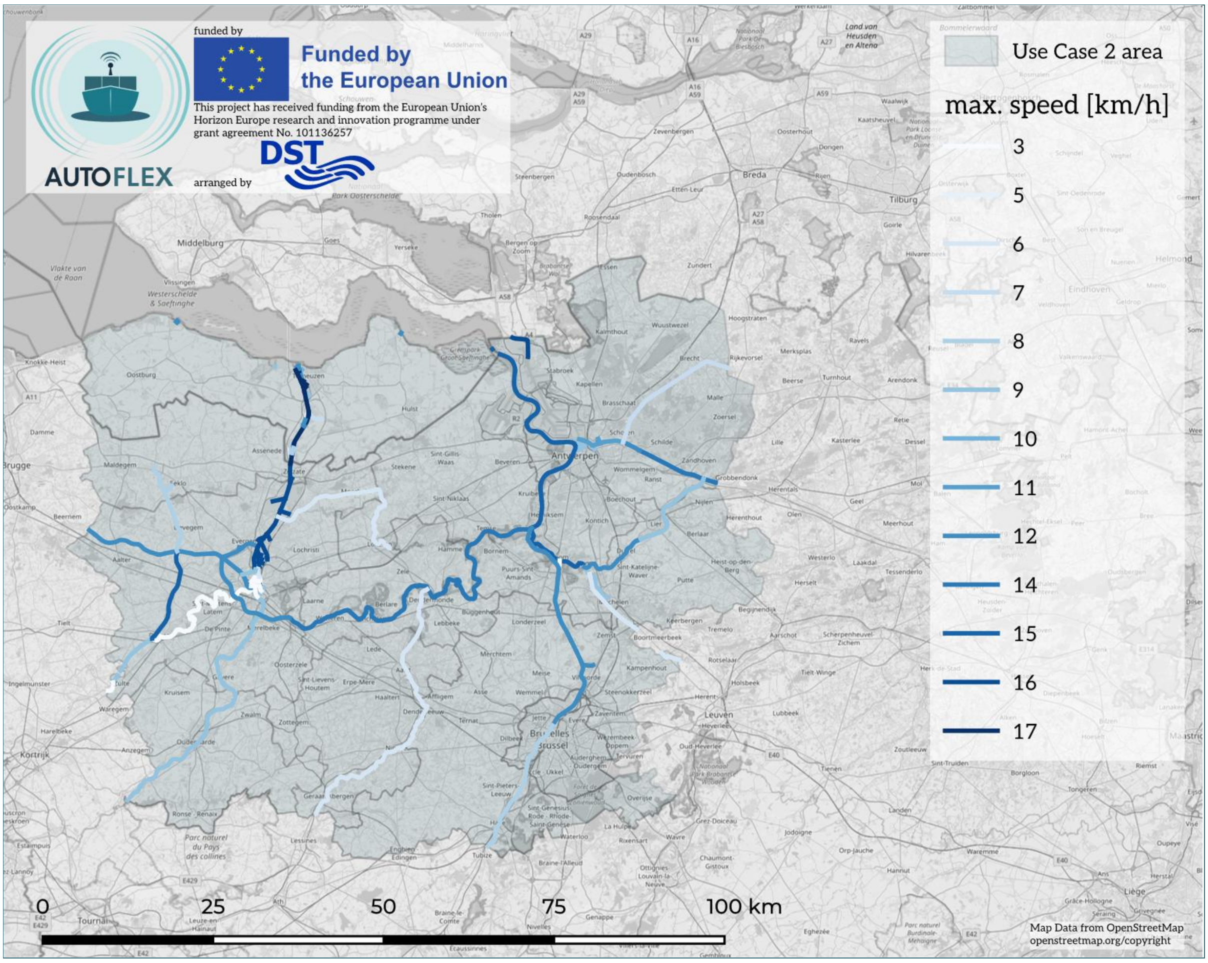

Figure 7-10: Speed limits on the inland waterways in the Use Case 2 area

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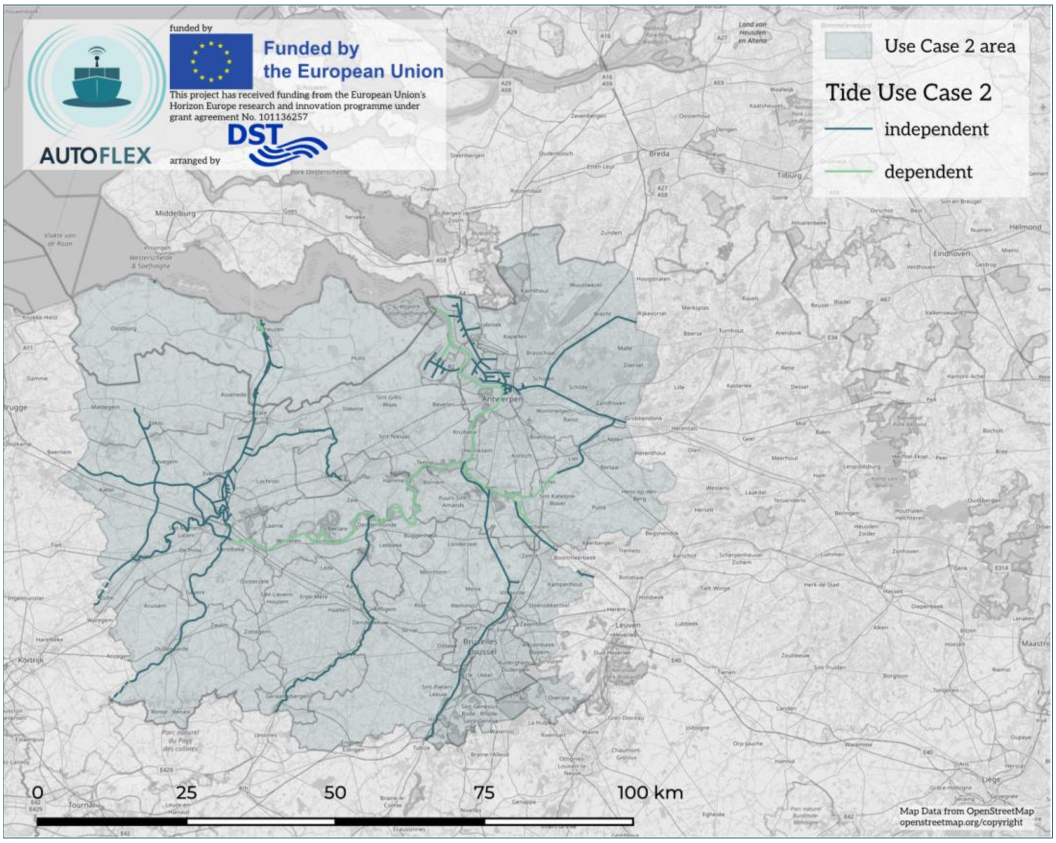

Figure 7-11: Tide-dependency of inland waterways in the Use Case 2 area

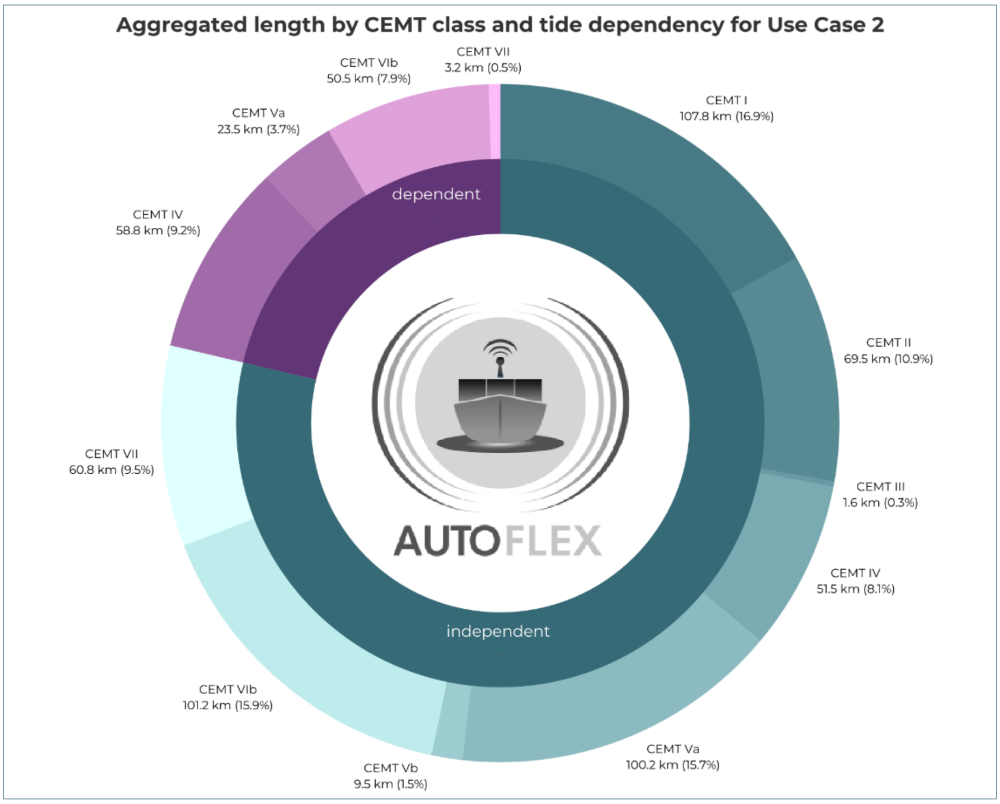

Figure 7-12: Proportion of tide-dependent inland waterways in the Use Case 2 area, differentiated by CEMT class

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7.2 BERTHS AND TRANSSHIPMENT POINTS

The Use Case 2 area in Belgium and the Netherlands comprises a total of 543 transshipment points, of which three terminals are dedicated to passenger transport. Two ferry terminals and a passenger terminal can be found in the considered geographic area whereas the residual 540 terminals are dedicated to freight transshipment. A total of 210 bulk terminals, 14 tank terminals and 12 container terminals, and one Ro-Ro terminal are located in the Use Case 2 area (see Figure 7-16).

With 303 transshipment points, the majority of terminals remains unspecified though. While the container terminals and the bulk terminals are scattered around the entire inland waterway network and the tank terminals are located in the vicinity of large chemical clusters, such as in Antwerp and Ghent, the large number of unspecified terminals can mainly be found along the Terneuzen-Ghent Canal and around the port of Antwerp. Figure 7-13 shows a map of all terminal locations, while Figure 7-14 and Figure 7-15 show dedicated maps of selected terminal types.

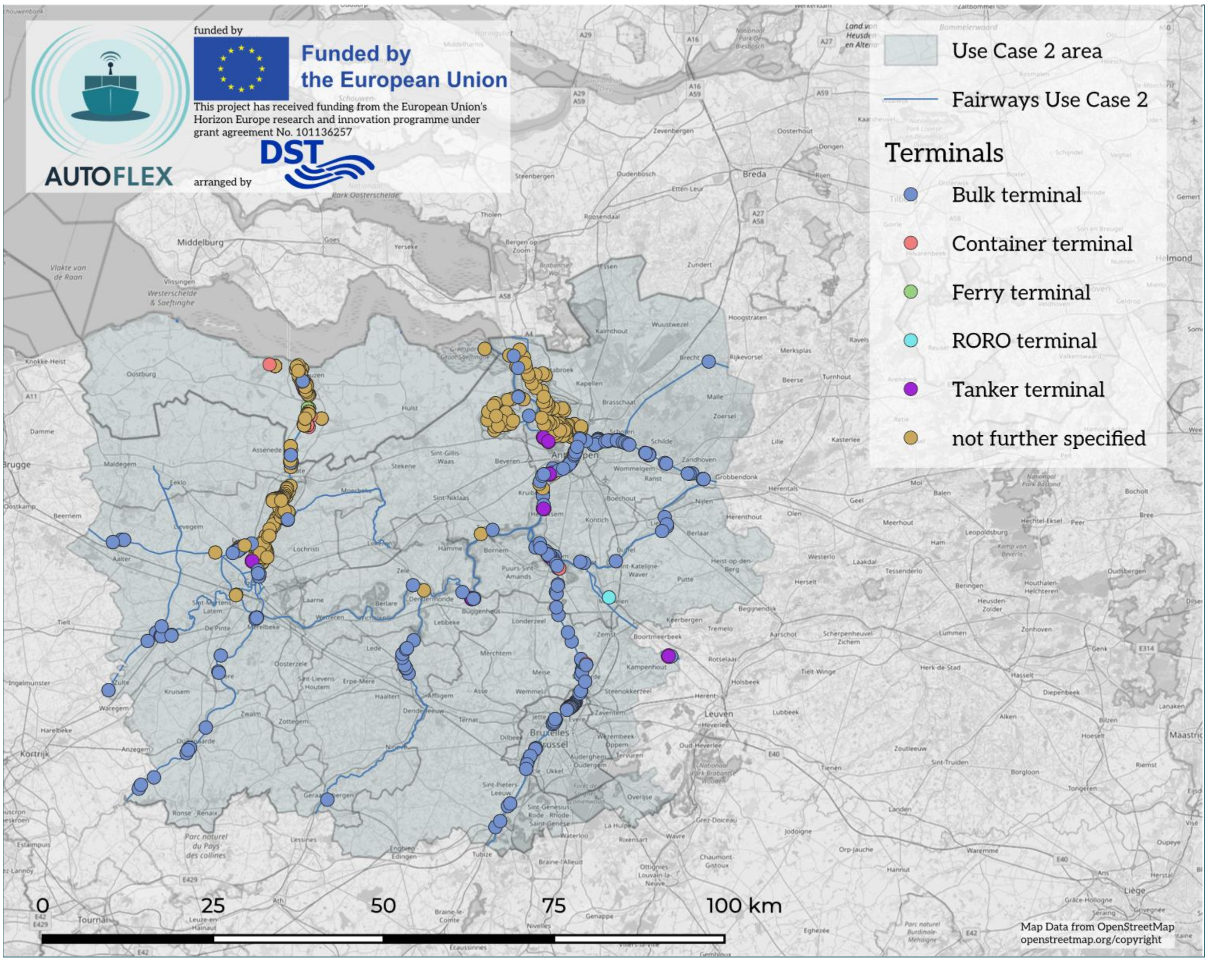

Figure 7-13: Types of terminals in the Use Case 2 area

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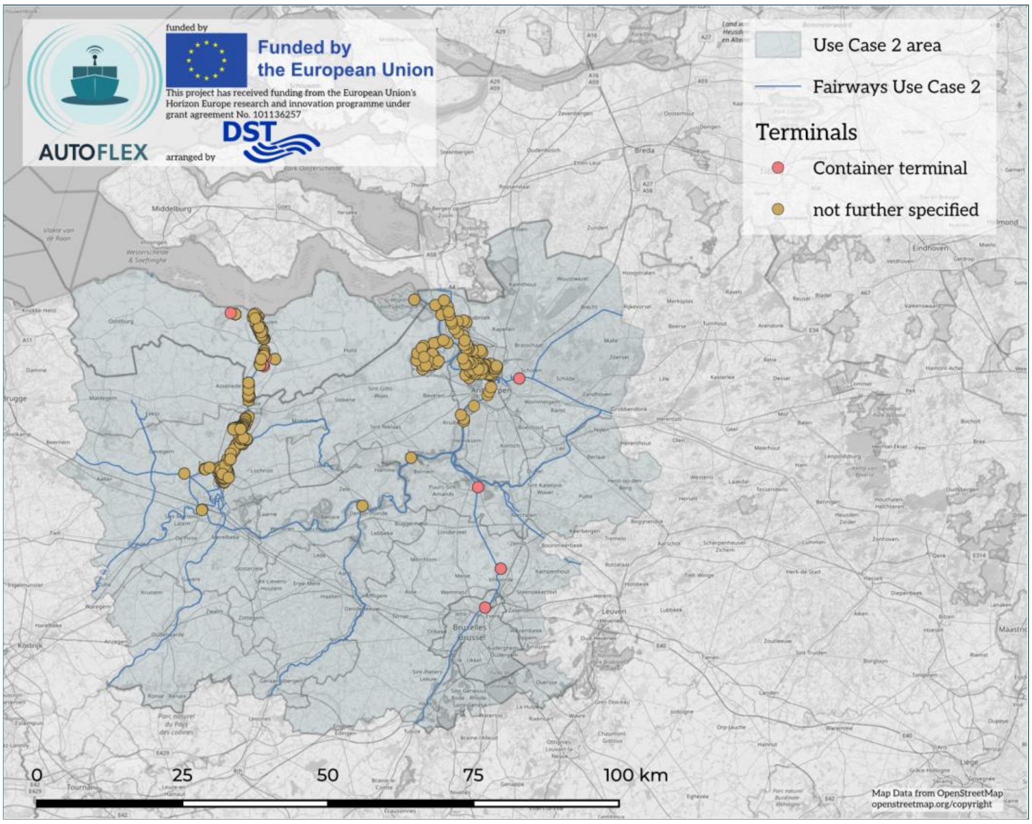

Figure 7-14: Container and uncategorised terminals in the Use Case 2 area

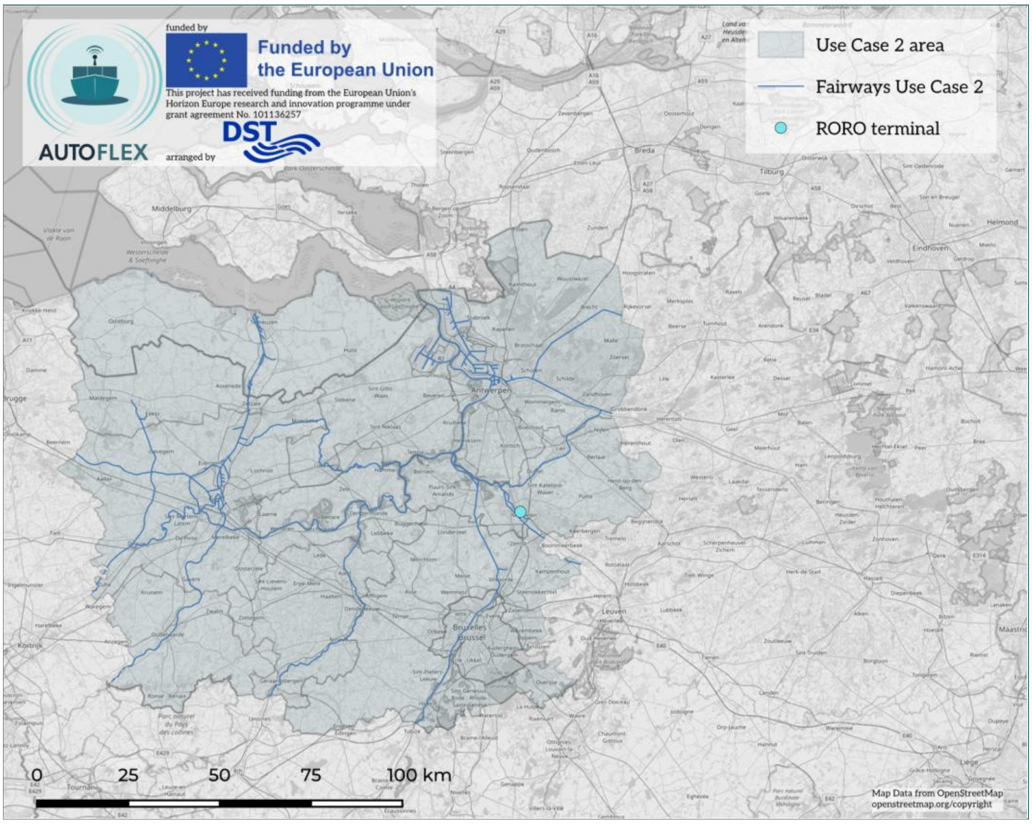

Figure 7-15: Ro-Ro terminals in the Use Case 2 area

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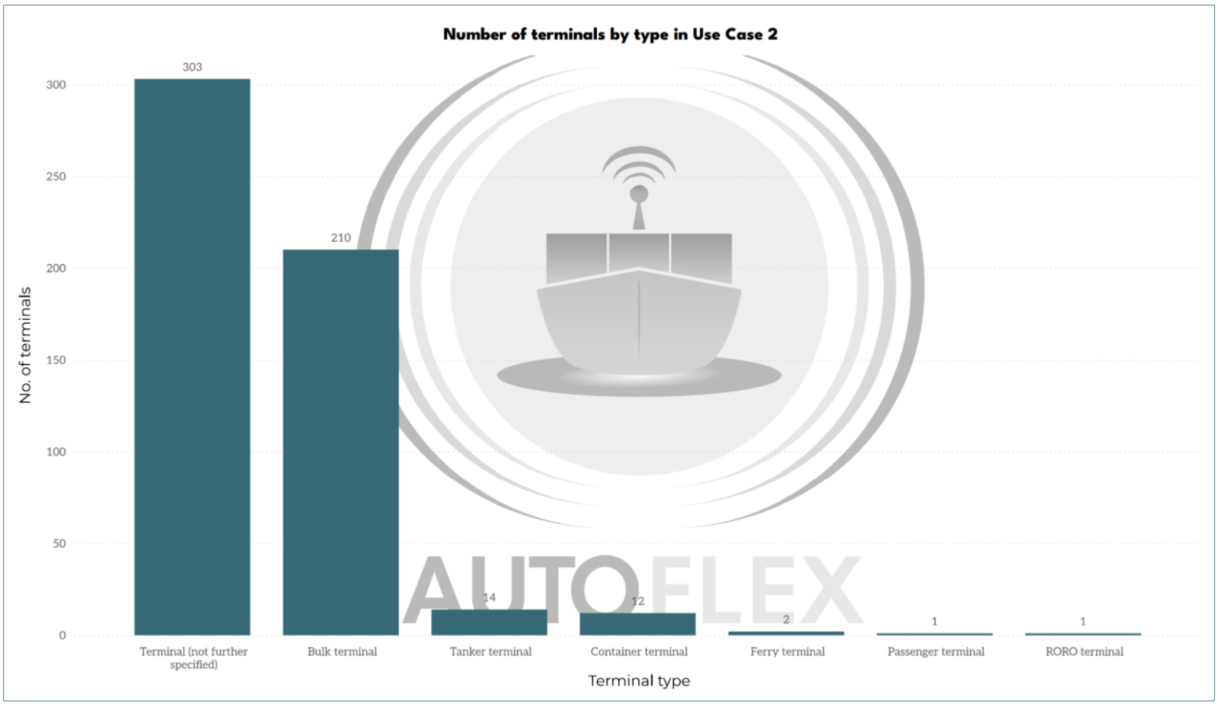

Figure 7-16: Proportion of terminals in the Use Case 2 area by type

As can be assumed that the unspecified terminals most probably handle different types of cargo, leaving the requirement of categorising the terminal hardly realisable, the largest portion of container transshipment takes place in and around Antwerp and between Terneuzen and Ghent. The rest of the network is well-endowed with bulk terminals and a few tank terminals which obviously form the backbone segments of the inland waterway transport business in Belgium (and parts of the Netherlands).

The number of berths in the Use Case 2 area amounts to 1,651 berthing locations, of which more than two thirds are transshipment berths and less than one third are berths without such facilities. Moreover, 99.7 percent of them are assigned to a terminal, with 1,087 out of 1,090 transshipment berths, so that independent transshipment facilities outside the dedicated terminal areas are an absolute exception. Hence, the solutions envisioned as part of the new AUTOFLEX transport system, such as the Stow & Charge hub, the mobile distribution centres, and particularly the temporary port terminals, can be realised either within the areas of existing terminals (and possibly conflicting with existing operations) or with the help of innovative concepts and solutions only. It is also noticeable that the axis from Antwerp via Brussels southwards to Charleroi (which lies outside the use case area) features significantly more berths than the axis from Terneuzen via Ghent to the southwest, i. e., to Kortrijk, Tournai or even French destinations (see Figure 7-17).

A closer look at the CEMT classes of the inland waterways on which the berths are situated reveals that most berths are assigned to CEMT class VII, i. e., which means that they are located in the port of Antwerp. Likewise, the inland waterways of the CEMT classes VI b and V a exhibit a larger number of berthing locations With respect to the smaller inland waterways (of the CEMT classes I to IV), only 215 berths are located on these, with 46 percent assigned to CEMT class IV and another 40 percent to CEMT class II. Since the AUTOFLEX inland vessels can also berth at locations designed for larger vessels, the

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situation looks favourable for operators of small inland vessels. Figure 7-18 presents the numbers of berths per CEMT class in the Use Case 2 area.

In order to see contextual implications of the above-mentioned data and statistics, particularly in geographic and nautical terms, a detailed analysis of the respective conditions is beneficial – as in the examples of Antwerp (see Figure 7-19) or Ghent (see Figure 7-20).

In the port cities of Antwerp and Ghent, it becomes evident which elevated significance the seaports and their terminals play for the operation of inland waterway transport both within the port and in the vicinity of it. A huge number of terminals and berths is available in the area. However, there are also significant differences: whereas Antwerp and its port hardly offers any opportunity to exploit untapped potential due to dedicated inland waterways for small inland vessels only (i. e., waterways of the CEMT classes I to IV), the city of Ghent does show such potential with several interconnections within the city and with a new transport corridor to the southwest.

The details of the 52 port cities in the Use Case 2 area (with their 543 terminals and 1,631 berths, of which 1,084 offer transshipment facilities) can be found in Table A-3 in the Appendix.

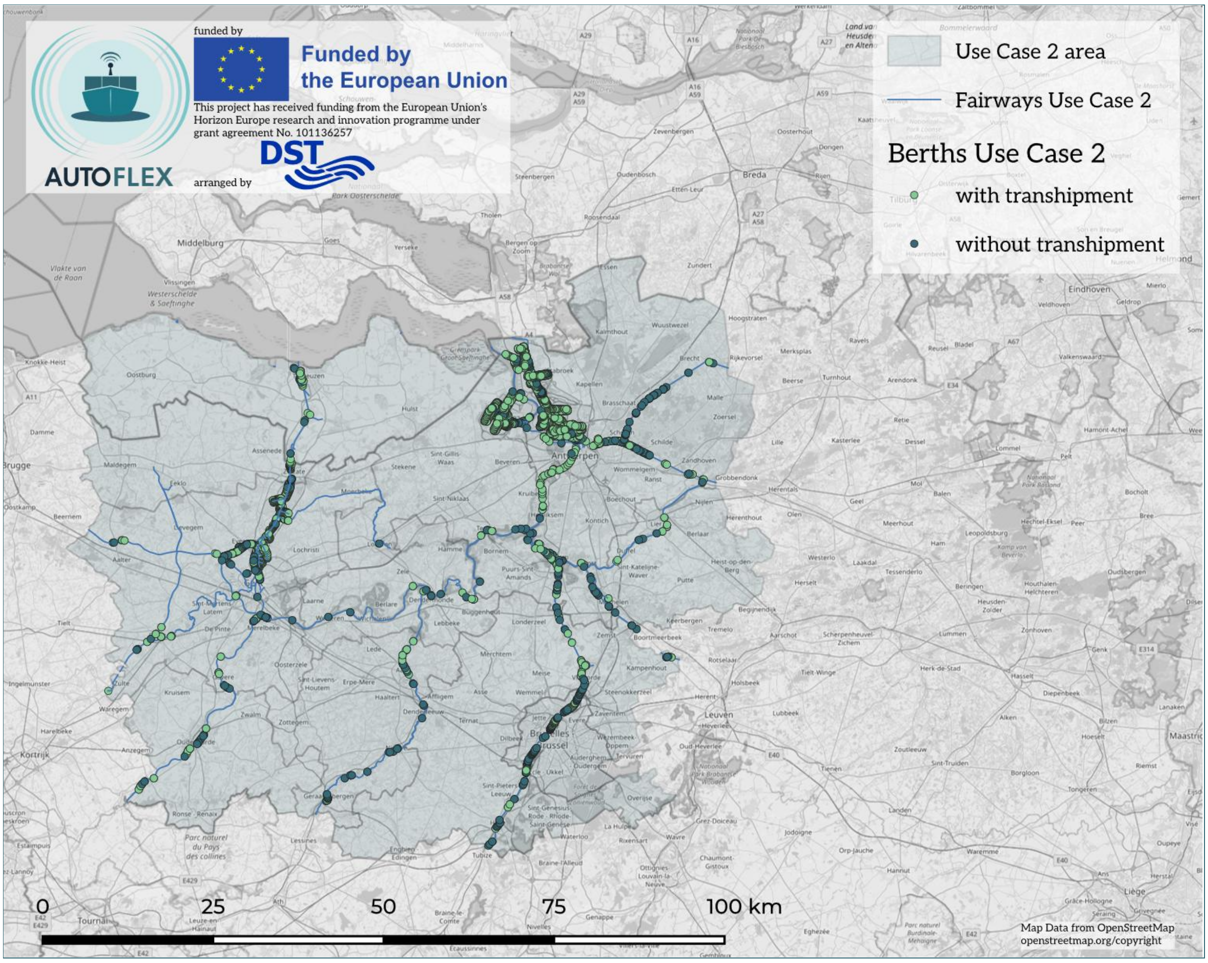

Figure 7-17: Berth types in the Use Case 2 area

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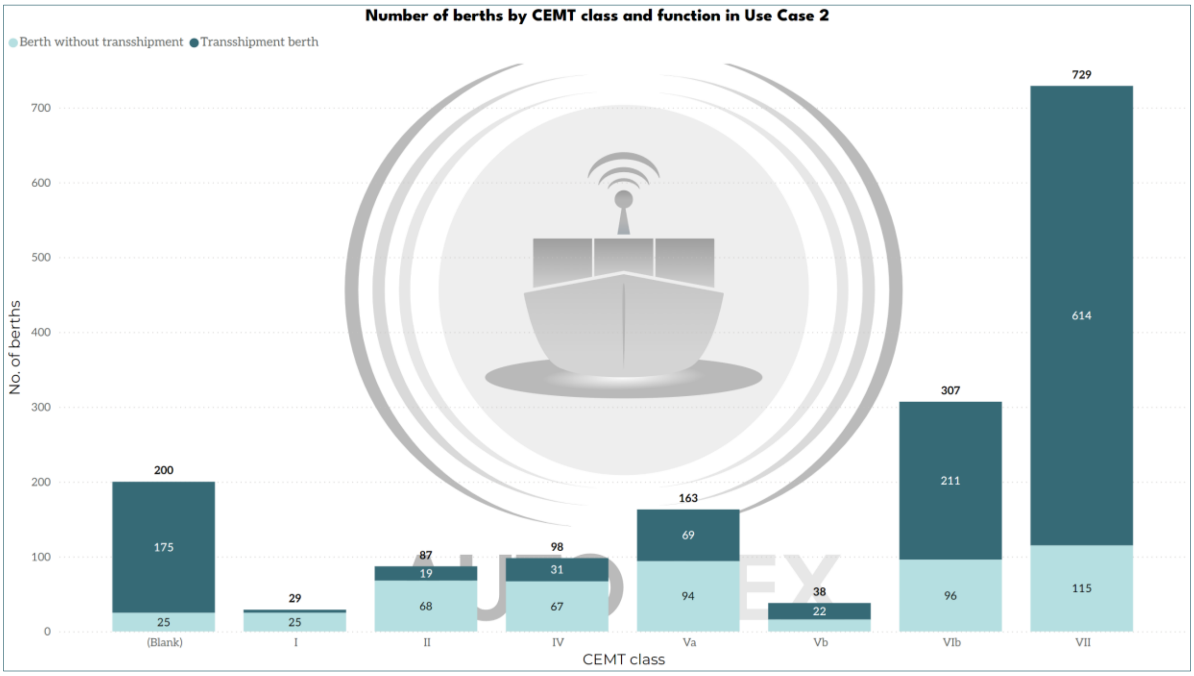

Figure 7-18: Number of berths with and without transshipment facilities per CEMT class in the Use Case 2 area

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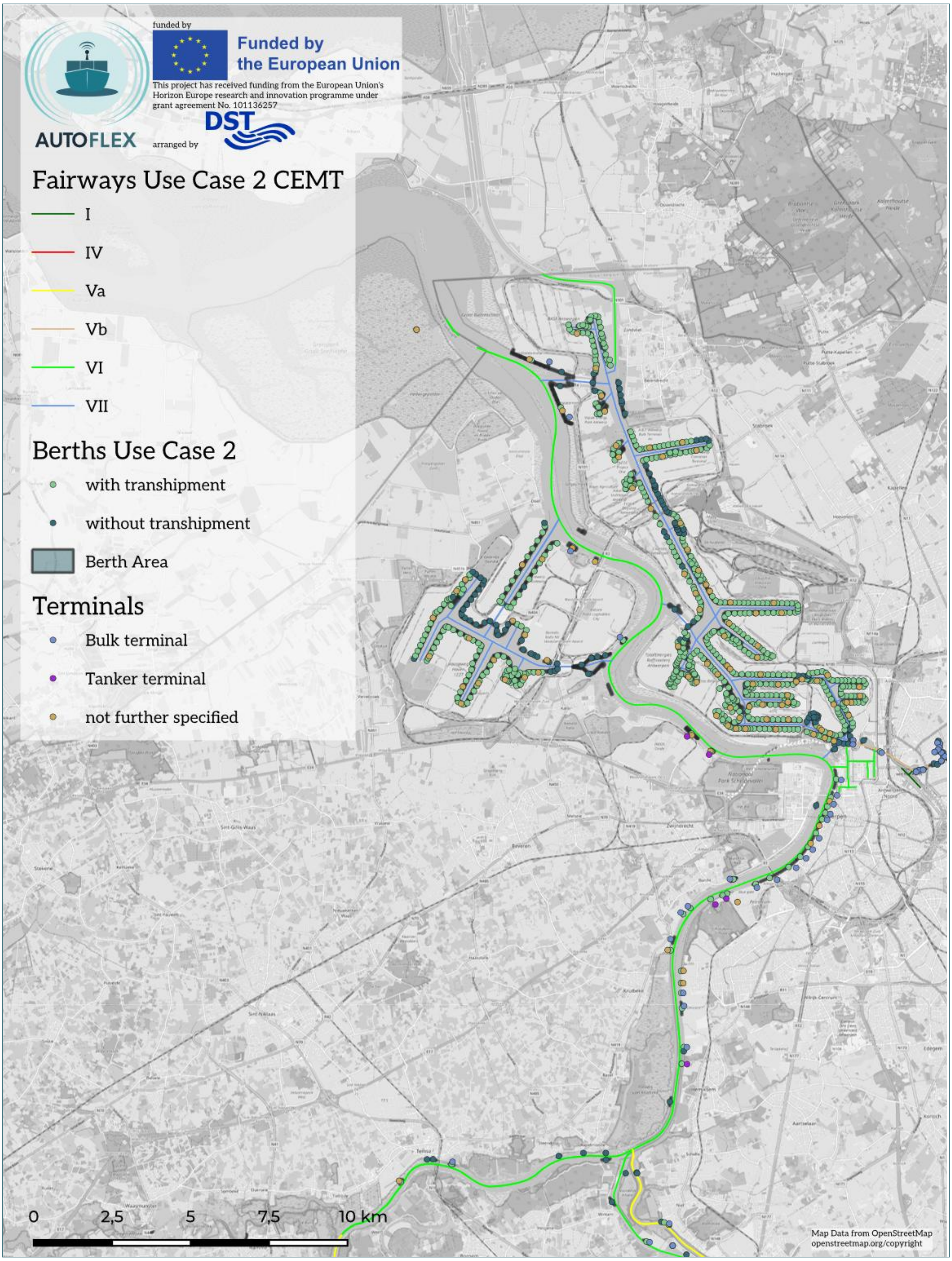

Figure 7-19: Terminals and berths in Antwerp, Belgium (BE211)

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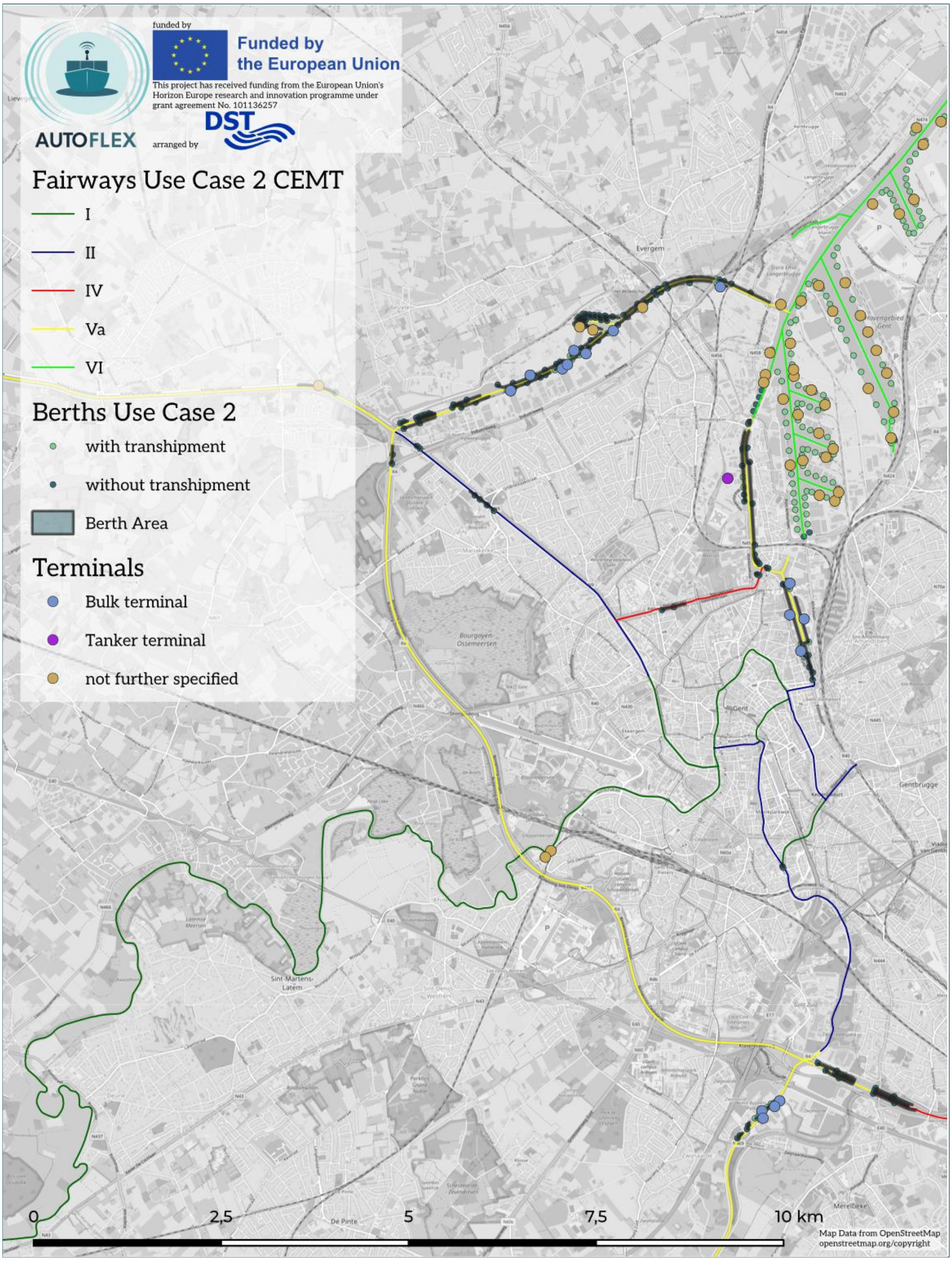

Figure 7-20: Terminals and berths in Ghent, Belgium (BE234)

7.3 LOCKS AND WEIRS

As visible in Figure 7-21, the locks in the Use Case 2 area are mainly situated in its southern and eastern part which is strongly linked to the underlying topography of the country and with desired control of the water flow in the canal network. Moreover, the port of Antwerp features a series of locks which allow passage to both sea-going and inland vessels. According to publicly available data, the Use Case 2 area does not feature any weirs but only 62 locks, of which the largest portion is situated on inland waterways of the CEMT classes II (with 15 locks), I, and V a (both with 11 locks each). Roughly half of the locks are categorised in one of the four CEMT classes I to IV, so that they are assigned to small inland waterways. Table 7-2 presents the numbers of locks per CEMT class, and Figure 7-23 the pertaining shares. The largest portion of the locks exhibits only one lock chamber whereas only exceptionally two or more lock chambers are available (and accessible) (see Figure 7-22).

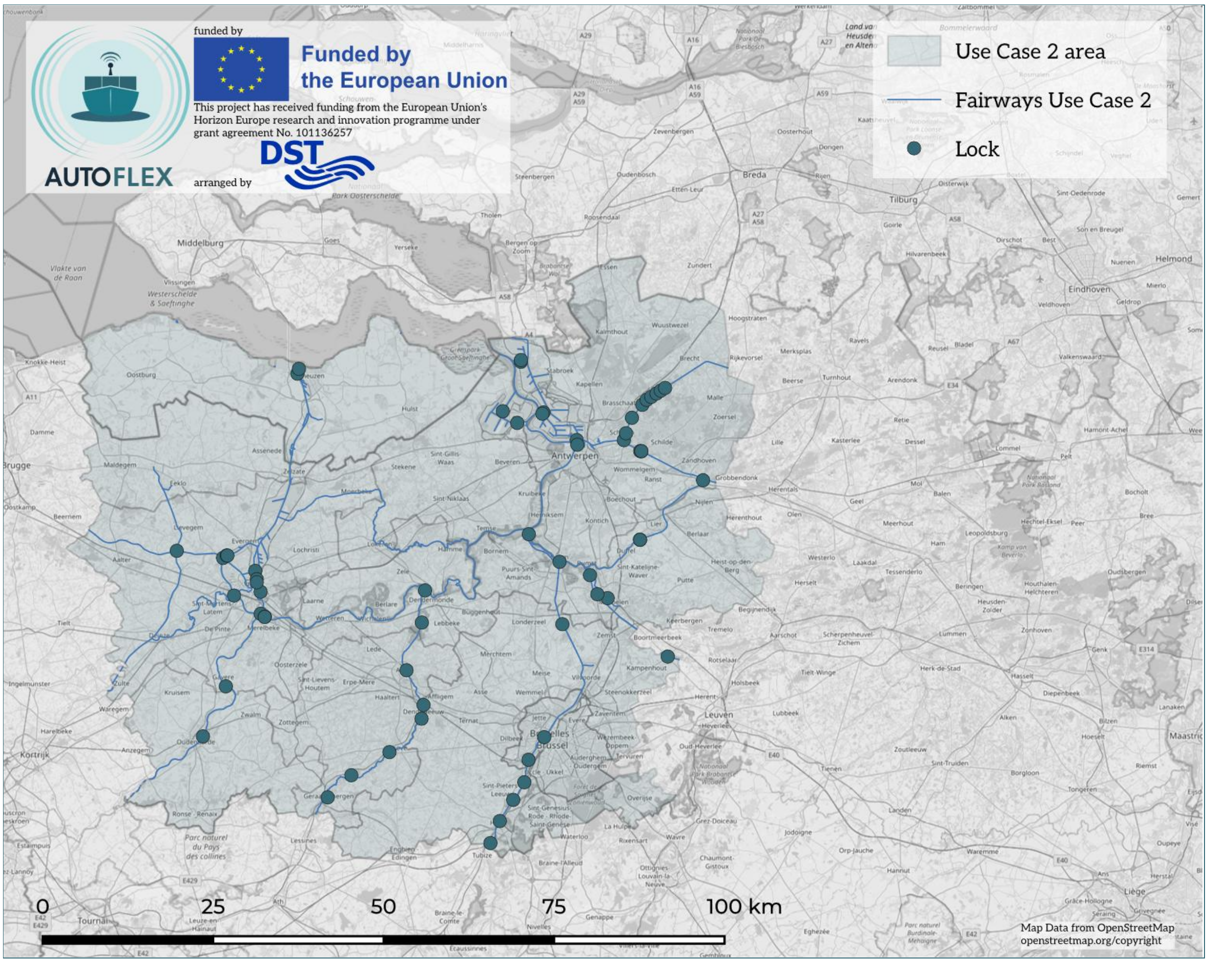

Figure 7-21: Locks in the Use Case 2 area

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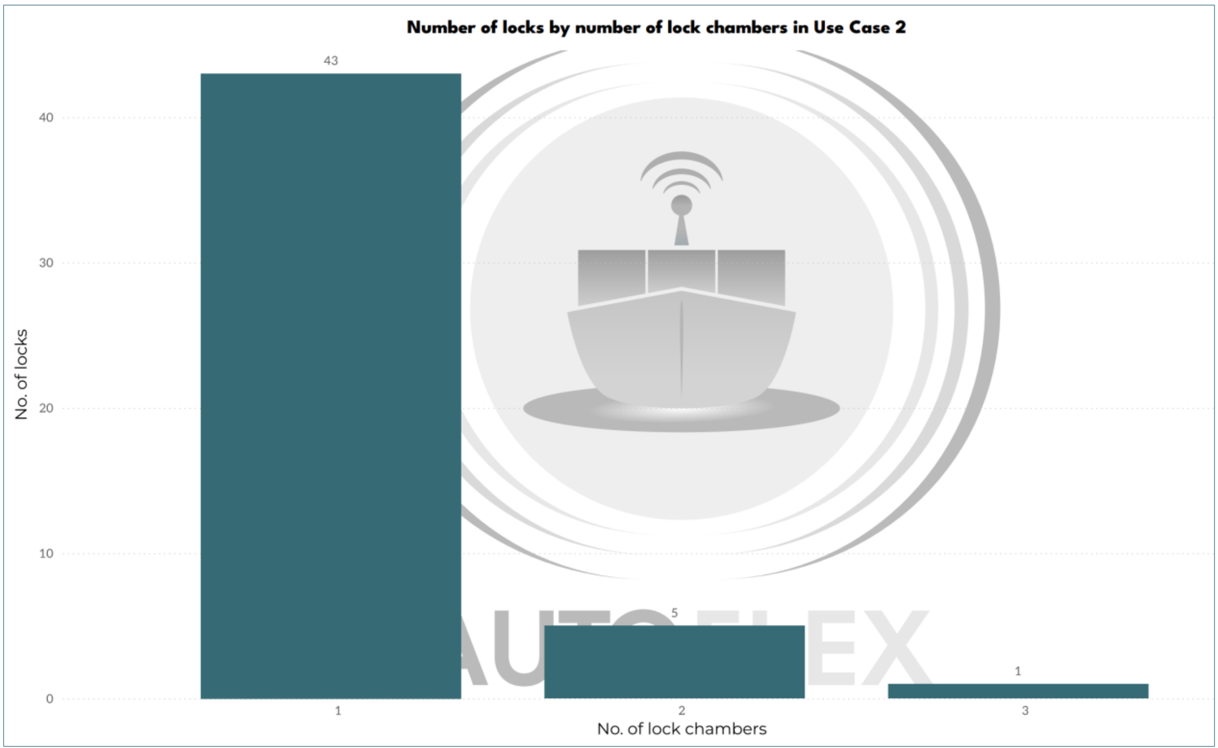

Figure 7-22: Number of lock chambers per lock in Use Case 2 area

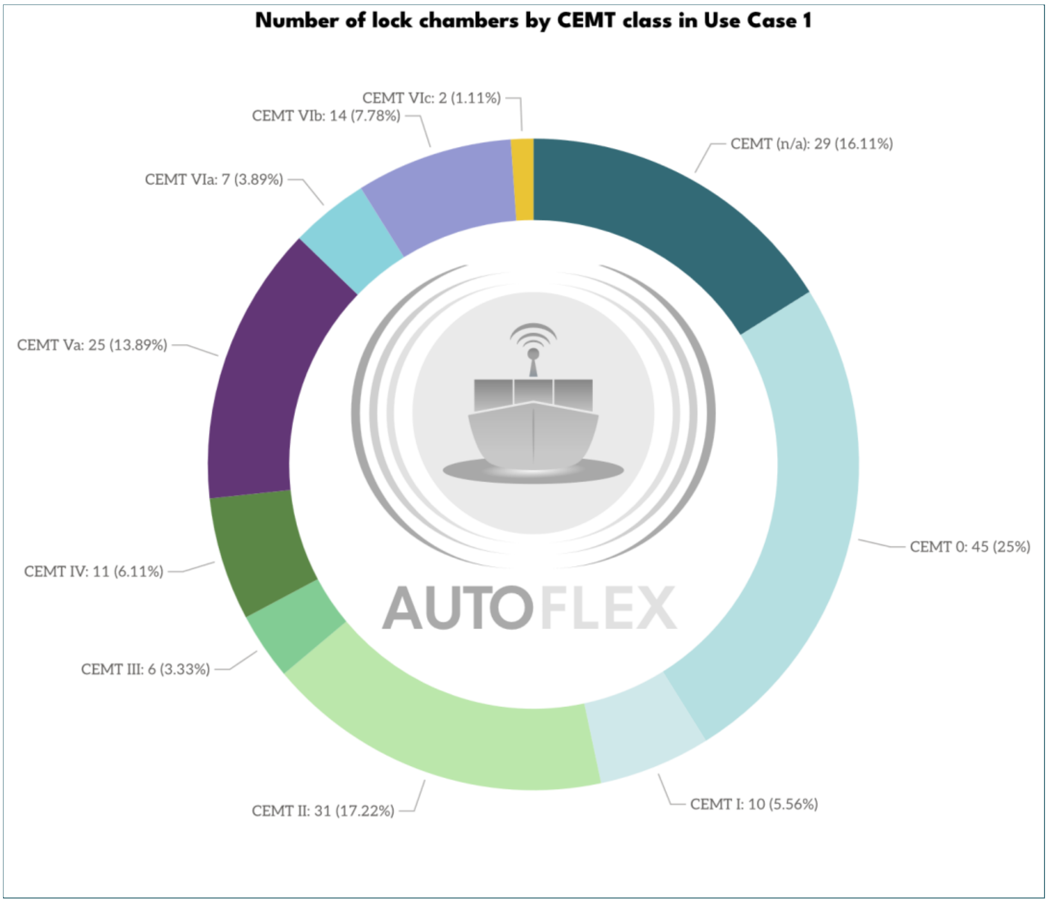

Figure 7-23: Number of locks per CEMT class in Use Case 2 area

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Table 7-2: Number of lock chambers per CEMT class in Use Case 2 area

CEMT class	n/a	I	II	IV	V a	VI b	VII	Total
Number of lock chambers	7	11	15	6	11	7	5	62

The two shortest locks of the Use Case 2 area cannot even be assigned to CEMT class I as they exhibit extraordinarily short lock chambers. The residual ones are 38.50 metres long which allows the accommodation of CEMT class I inland vessels. The list of the shortest locks is visible in Table 7-3.

Analogously, Table 7-4 shows the narrowest locks. While the narrowest lock would not even allow the width of a CEMT class I vessel, the widths of the residual locks (with a width of 5.10 metres) on the list match the width requirements of a CEMT class I inland vessel and lock (i. e., 5.05 metres).

An analysis of the locks in the Use Case 2 area and particularly of the small locks yields that many locks are rather small medium-sized while some are capable of accommodating large sea-going vessels as well, particularly within the port of Antwerp and on the Terneuzen-Ghent Canal. The distribution of the locks can be seen in Figure 7-24 and Figure 7-25.

Table 7-3: Shortest locks in the Use Case 2 area

Name	Permitted vessel length [m]	CEMT class
Scaldissluis kolk	13.00	(0)
St. Jorissluis te Gent kolk	15.00	(0)
Sluis te Aalst kolk	38.50	I
Sluis te Teralfene kolk	38.50	I
Sluis te Geraardsbergen kolk	38.50	I
Sluis te Idegem kolk	38.50	I
Brusselsepoortsluis kolk	38.50	I
Keersluis K2 te Gent kolk	38.50	I
Sluis te Pollare kolk	38.50	I
Sluis te Schipdonk kolk	38.50	I

Table 7-4: Narrowest locks in the Use Case 2 area

Name	Permitted vessel width [m]	CEMT class
Scaldissluis kolk	4.50	(0)
Sluis te Aalst kolk	5.10	I
Sluis te Teralfene kolk	5.10	I
Sluis te Denderleeuw kolk	5.10	I
Sluis te Geraardsbergen kolk	5.10	I
Sluis te Idegem kolk	5.10	I

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Brusselsepoortsluis kolk	5.10	I
Keersluis K2 te Gent kolk	5.10	I
St. Jorissluis te Gent kolk	5.10	I
Sluis te Pollare kolk	5.10	I
Sluis te Schipdonk kolk	5.10	I

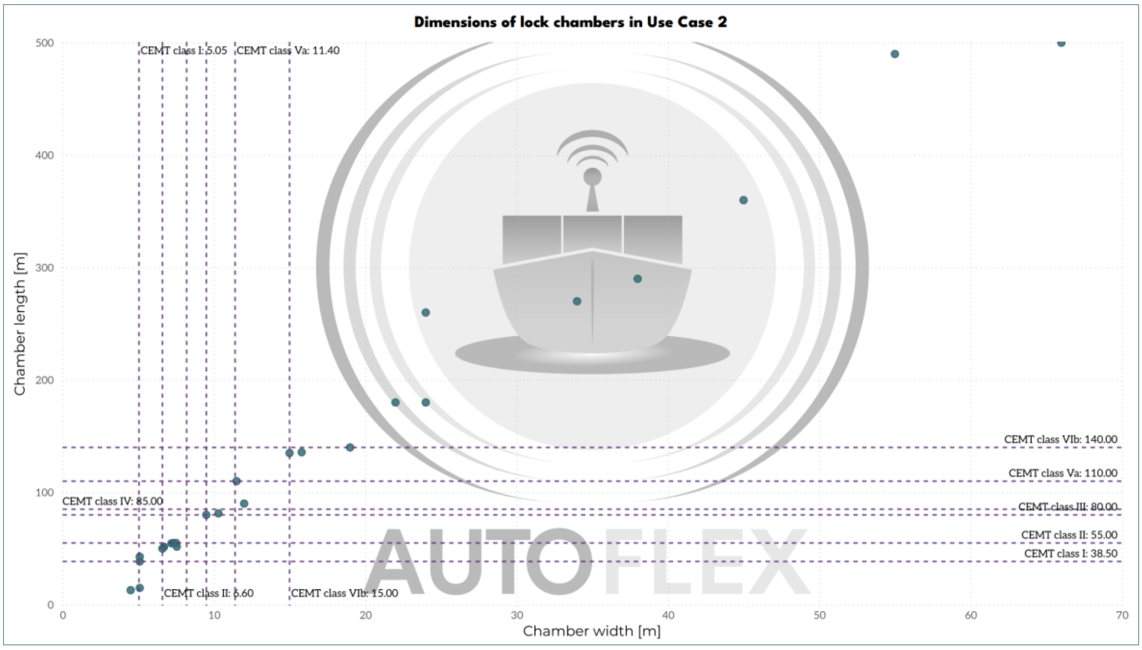

Figure 7-24: Distribution of locks in the Use Case 2 area per CEMT class

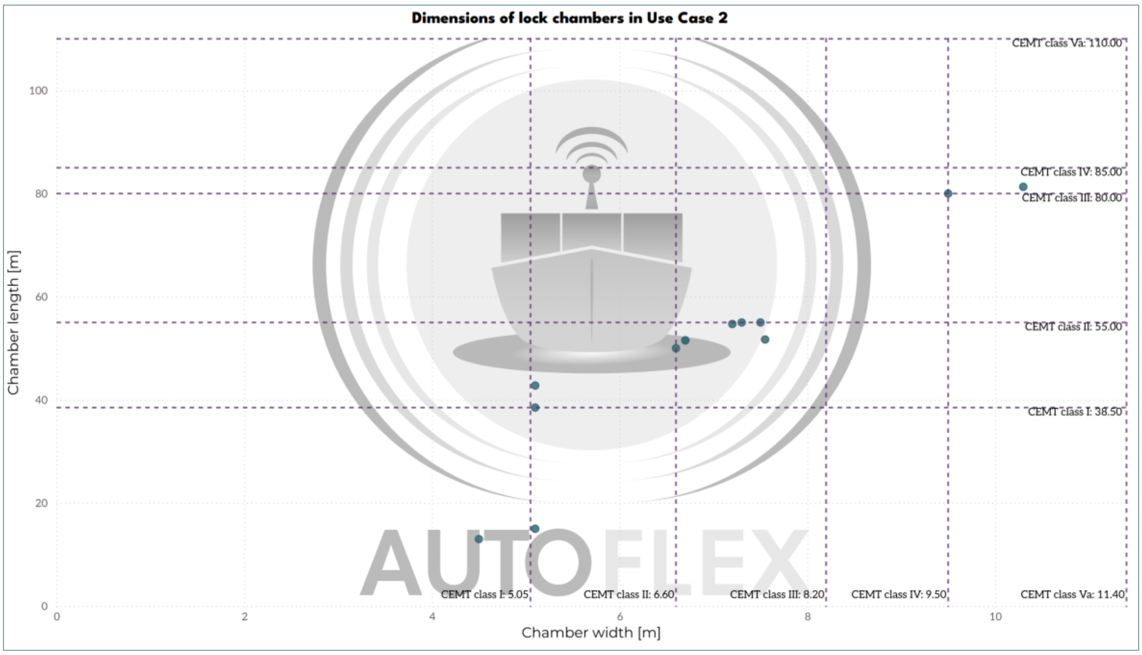

Figure 7-25: Distribution of small locks in the Use Case 2 area per CEMT class

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7.4 BRIDGES AND OVERHEAD STRUCTURES

There are 413 bridges on inland waterways in the Use Case 2 area. Some of the bridges may be combined in bridge constructions whereas the large majority, more precisely, more than 80 percent, are stand-alone structures. Only very few bridge constructions in the considered geographic area have two or more bridge openings, as can be seen in Figure 7-26.

With respect to the bridge types in the Use Case 2 area, virtually all types of bridge and overhead structures can be found in the area. Apart from fixed bridges forming the large majority of bridge structures with over 70 percent, bascule bridges (13 percent) and drawbridges (5.5 percent) are the next types on the list in descending number of occurrence. Figure 7-27 shows the bridges on a map whereas Figure 7-29 illustrates the proportional share of each type in the total number. Figure 7-28 shows a spatial distribution of the bridges, differentiated by movability. Interestingly, the movable bridges occur in accumulations of a few units in a row, such as on the Terneuzen-Ghent Canal, the Albert Canal, the Brussels-Scheldt Canal, and in the ports of Antwerp and Ghent. Nearly three quarters of all bridge structures are fixed whereas the remaining quarter is movable.

Due to the occasionally critical bridge passage by inland vessels, the bridge height is crucial information for the vessel design process: the height of the fixed bridges on CEMT class I and II inland waterways typically range between 2.50 metres and 5.00 metres and between 5.00 metres and 6.50 metres, respectively. For bridges on CEMT class IV inland waterways, the corresponding values typically lie between 5.50 metres and 7.75 metres. The median height rises from 4.25 metres and 5.50 metres for the small waterways to 9.27 metres (class V b). Unlike in the Use Case 1 area in which the bridges on the larger CEMT classes were significantly higher than the ones on the smaller waterways, the bridges on the larger inland waterways in the Use Case 2 area are in the same height range as the bridges on the CEMT class IV waterways. Figure 7-30 presents the height distribution of the fixed bridges in the Use Case 2 area.

The lowest fixed bridge in the Use Case 2 area is so low that it does not allow passage – not even in empty state. The other bridges on the list shown in Table 7-5 allow passage of the AUTOFLEX CEMT class IV inland vessel with its higher draft when loaded with one or more container layers compared to its CEMT class II counterpart. Even for the latter vessel, only two bridges appear impassable when loaded with one container layer. However, this consideration lacks the check whether the respective inland vessel type could navigate on the waterway at all. When taking that aspect also into account, the AUTOFLEX CEMT class II inland vessel cannot pass one bridge in the Use Case 2 area – exactly the same one that the AUTOFLEX CEMT class IV inland vessel cannot pass either (see Table 7-6 and Table 7-7). As only bridge openings on inland waterways of CEMT classes II and higher have been included in the earlier case – and bridge openings on inland waterways of CEMT classes IV and higher for the latter one, the above-mentioned bridge can be assumed to be situation on an inland waterway of CEMT class IV or higher. Moreover, it is striking that the lowest bridges in the Use Case 2 area are still high enough to facilitate double-layer container transport, except for two bridges in the case of the AUTOFLEX CEMT class II inland vessel and merely one in the case of the AUTOFLEX CEMT class IV inland vessel.

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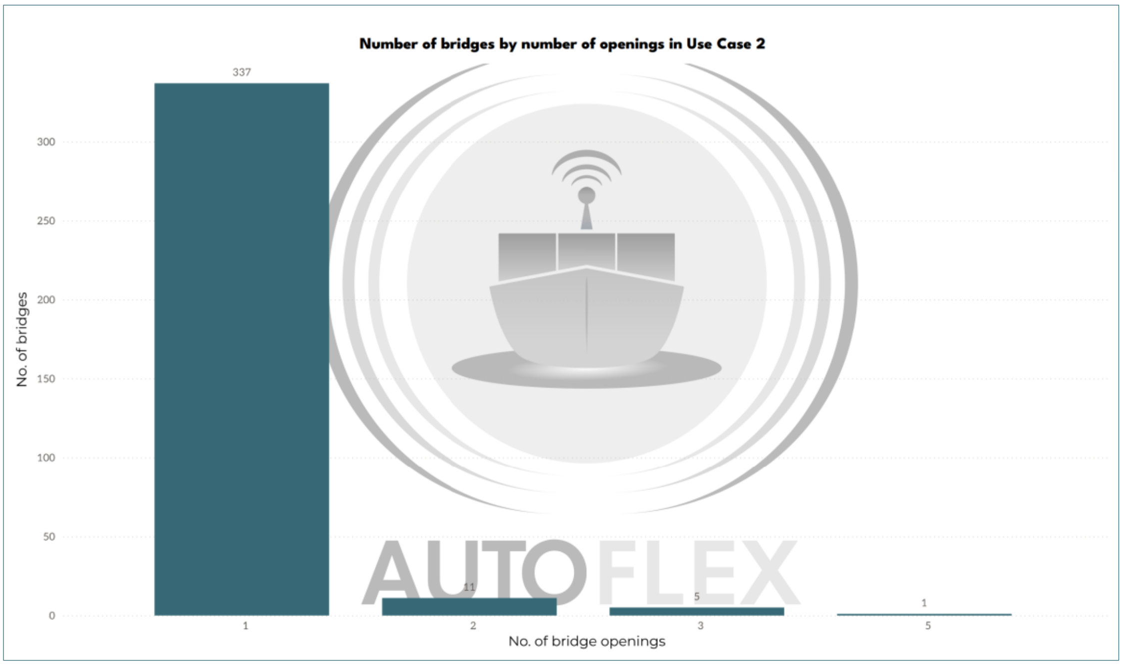

Figure 7-26: Number of bridges with one or several bridge openings in the Use Case 2 area

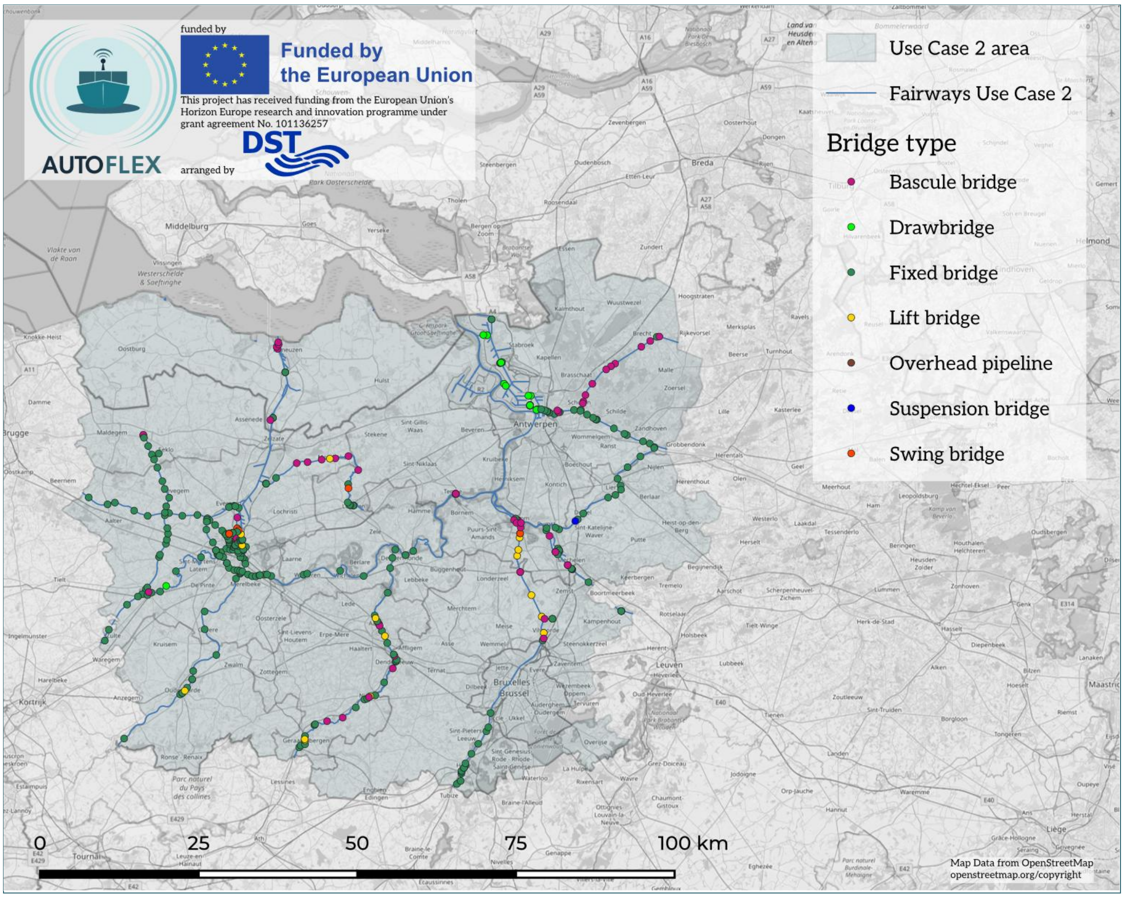

Figure 7-27: Types of bridges in the Use Case 2 area[62]

[62] Display per bridge opening

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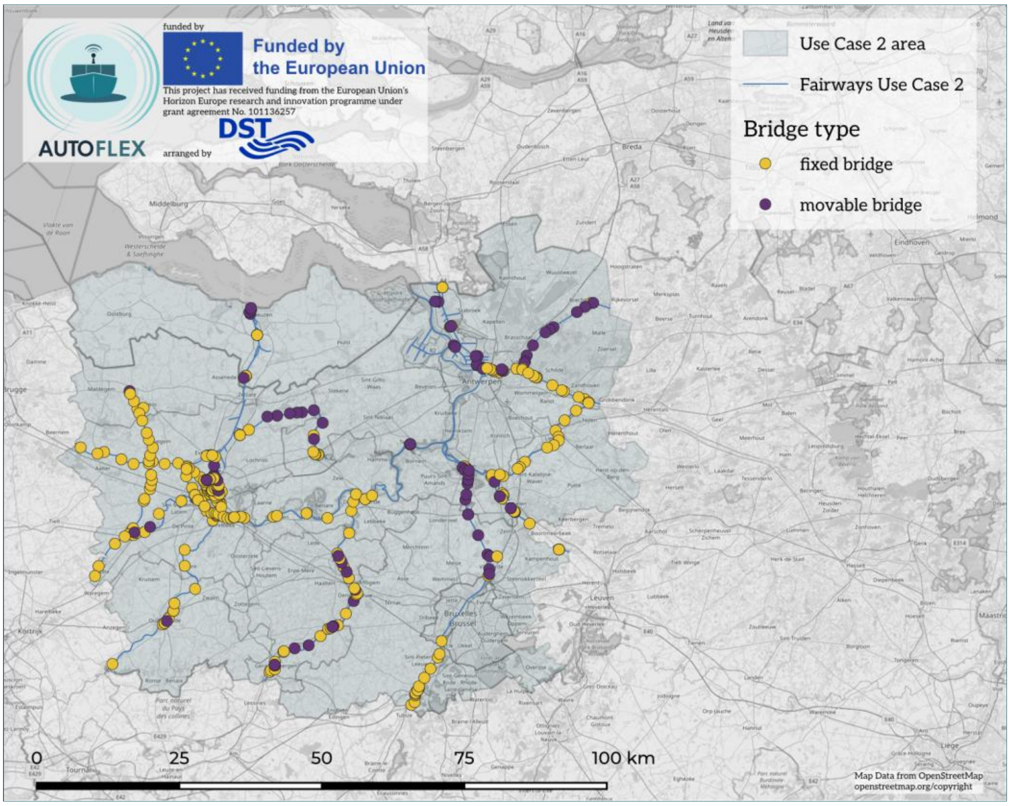

Figure 7-28: Fixed and movable bridges in the Use Case 2 area[63]

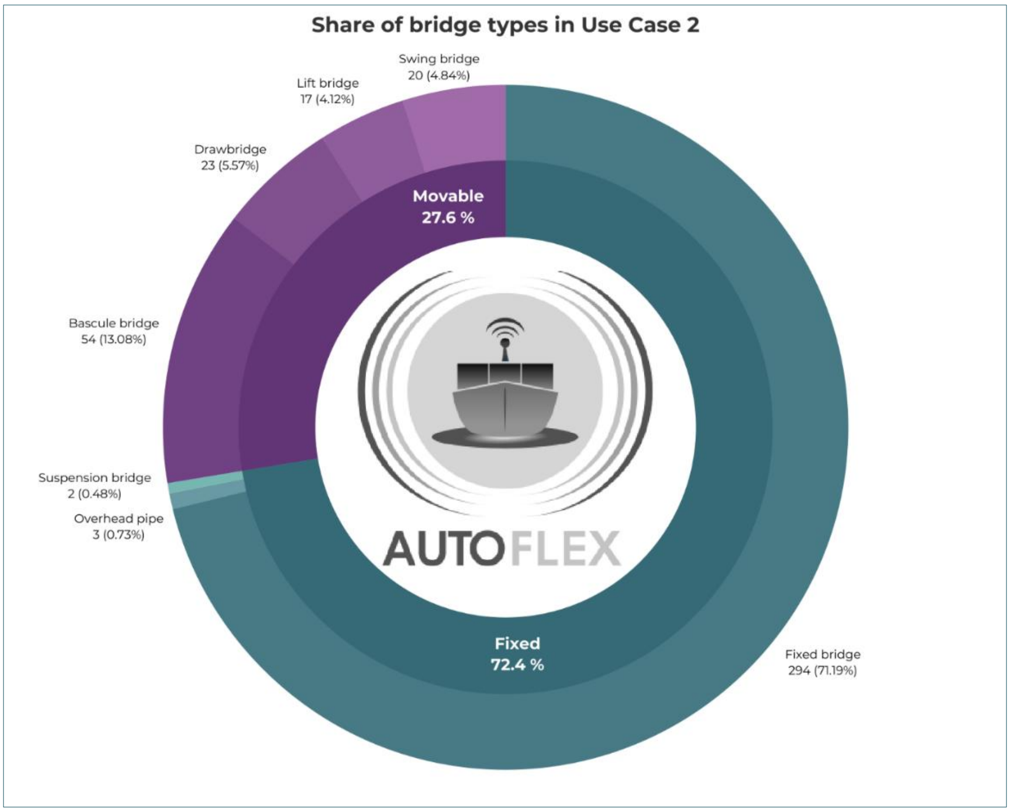

Figure 7-29: Proportion of fixed and movable bridges in the Use Case 2 area

[63] Display per bridge opening

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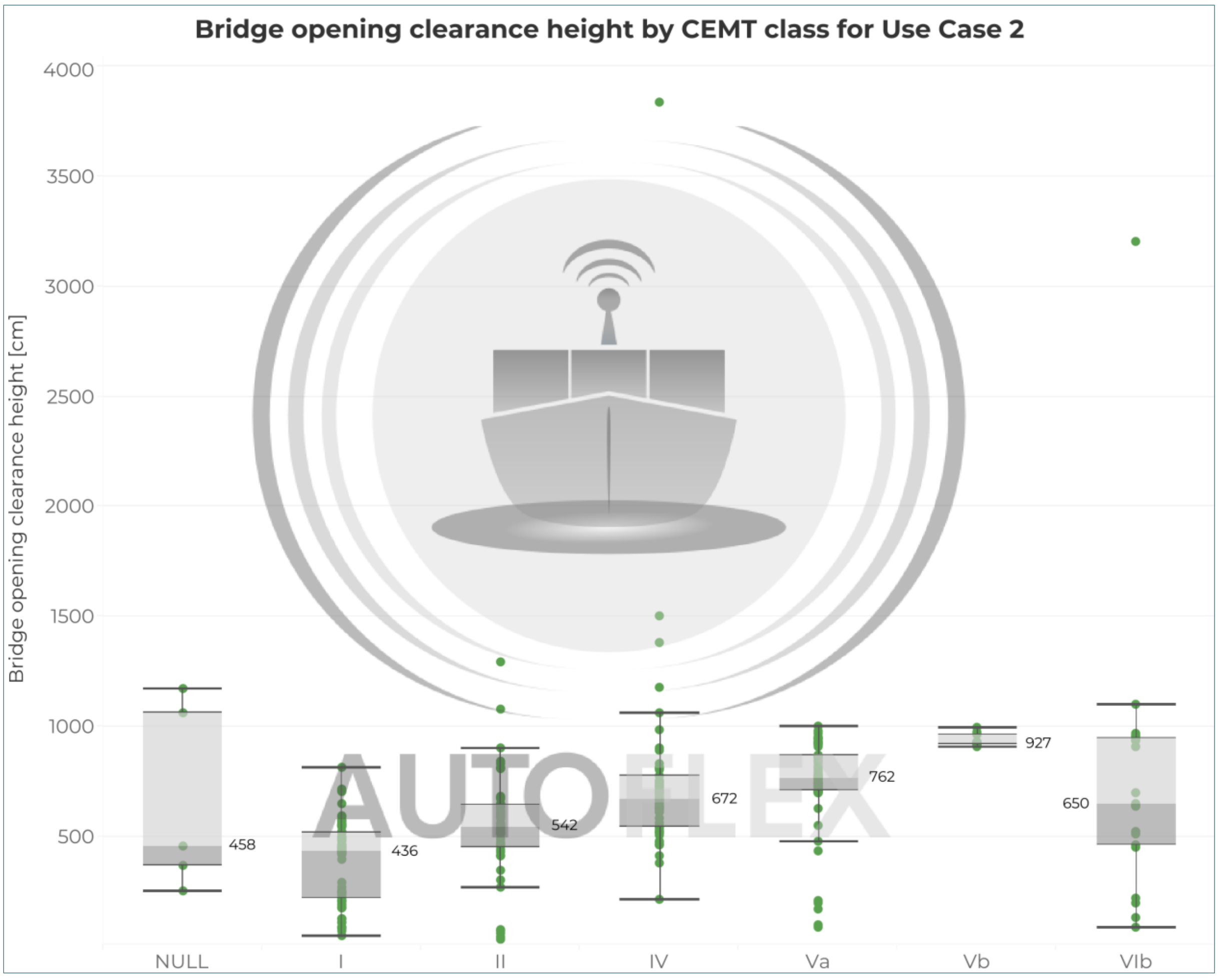

Figure 7-30: Heights of bridge openings of fixed bridges in the Use Case 2 area

Table 7-5: Lowest bridge openings of fixed bridges in the Use Case 2 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of cont. layers (CEMT II)**	**Permissible no. of cont. layers (CEMT IV)**
Spoorbrug Boom opening 2	0.88	impassable	impassable
Spoorbrug	1.86	impassable	1
Contributiebrug (Nieuwe Wandeling)	2.21	1	1
Bavobrug	2.30	1	1
Hospitaalbrug	2.45	1	1
St. Agnetabrug	2.45	1	1
Rozemarijnbrug	2.93	1	1
Waasmunsterbrug	3.69	1	2
Baanbrug Duffel	3.81	1	2
Spoorbrug Brussel-Oostende te Aalst kmp 50.6	3.97	1	2

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Table 7-6: Lowest bridge openings of fixed bridges on the waterways accessible to the AUTOFLEX CEMT class II inland vessel in the Use Case 2 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of container layers (CEMT II)**
Spoorbrug Boom opening 2	0.88	impassable
Baanbrug Duffel	3.81	1
Marcellisbrug	4.10	2
Baanbrug Walem	4.11	2
Ketelbrug	4.13	2
Voetbrug Beukelaarstraat	4.30	2
Baanbrug Boom opening 2	4.34	2
Muinkbrug	4.42	2
Walpoortbrug	4.54	2
Brug afwaarts sluis Ruisbroek	4.60	2

Table 7-7: Lowest bridge openings of fixed bridges on the waterways accessible to the AUTOFLEX CEMT class IV inland vessel in the Use Case 2 area

Name (of bridge opening)	**Bridge clearance height** [m]	**Permissible no. of container layers (CEMT IV)**
Spoorbrug Boom opening 2	0.88	impassable
Baanbrug Duffel	3.81	2
Baanbrug Walem	4.11	2
Baanbrug Boom opening 2	4.34	2
Brug afwaarts sluis Ruisbroek	4.60	2
Bospoortbrug	4.63	2
Brug afwaarts sluis Lot	4.73	2
Tolhuisbrug	4.80	2
Brug - R0	4.80	2
Brug 036-1	5.06	2

A look at the maps depicted in Figure 7-31, Figure 7-32, Figure 7-33, and Figure 7-34 confirms that the AUTOFLEX CEMT class II inland vessel cannot pass a few movable bridges when remaining idle and exactly that above-mentioned fixed bridge situated between Antwerp and Brussels (whose lifting or replacement could be a recommendation to policy-makers of the pertaining geographic area). In the case of the AUTOFLEX CEMT class IV inland vessel, a similar picture is visible with a few impassable movable bridges and – again – that one fixed bridge mentioned before (see Figure 7-35, Figure 7-36, Figure 7-37, and Figure 7-38).

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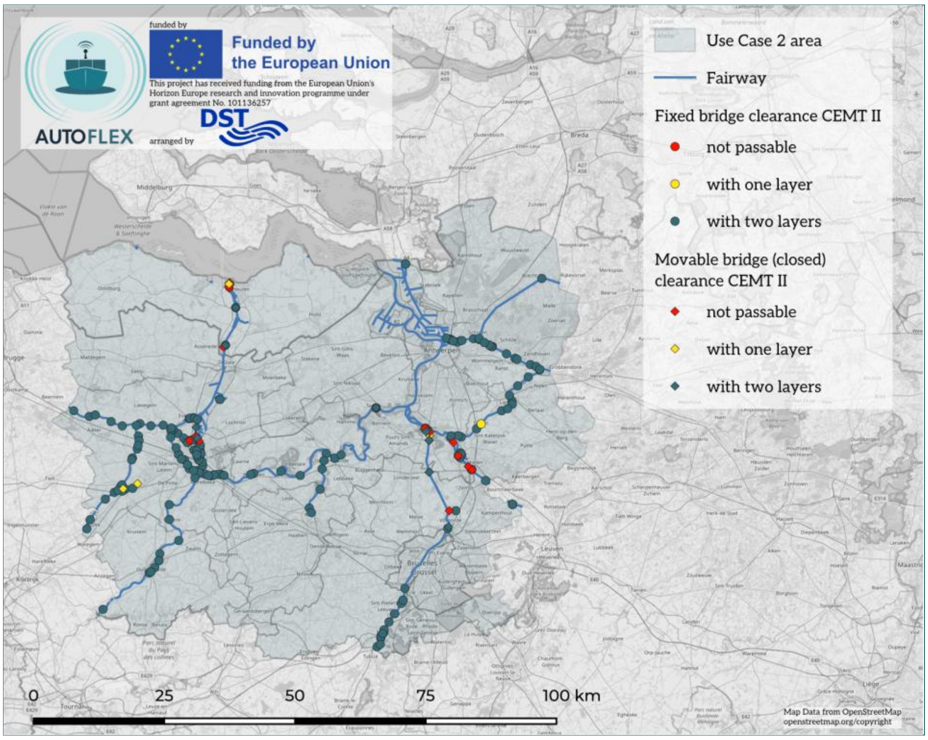

Figure 7-31: Clearance heights of all bridges on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class II vessel)[64]

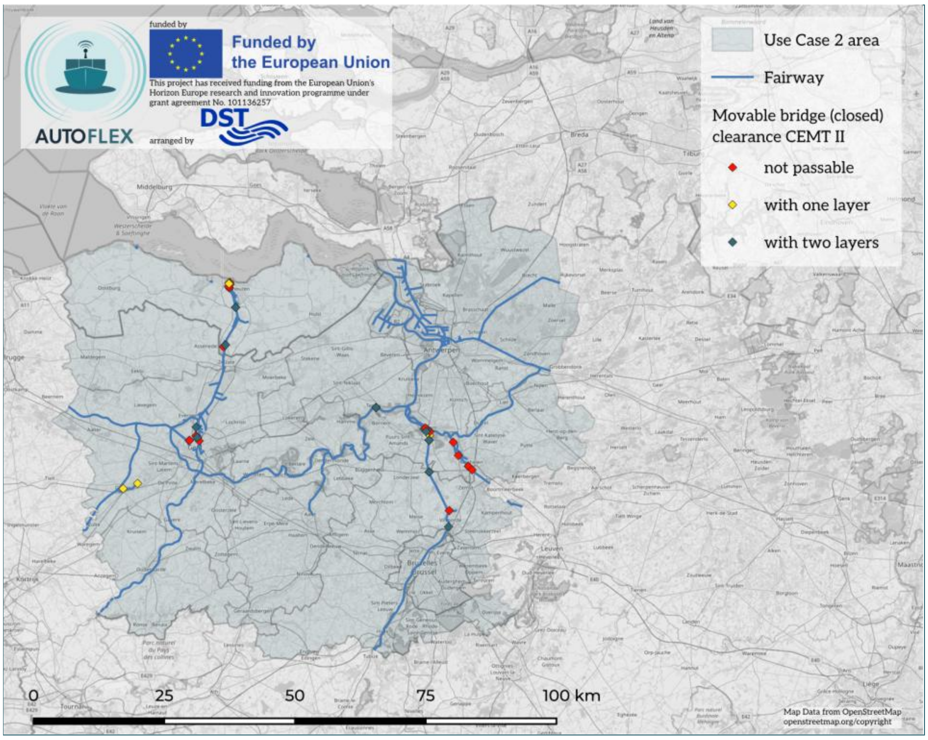

Figure 7-32: Clearance heights of the movable bridges (in closed state) on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class II vessel)[65]

[64] Display per bridge opening; movable bridges are assumed as unoperated (closed)
[65] Display per bridge opening; movable bridges are assumed as unoperated (closed)

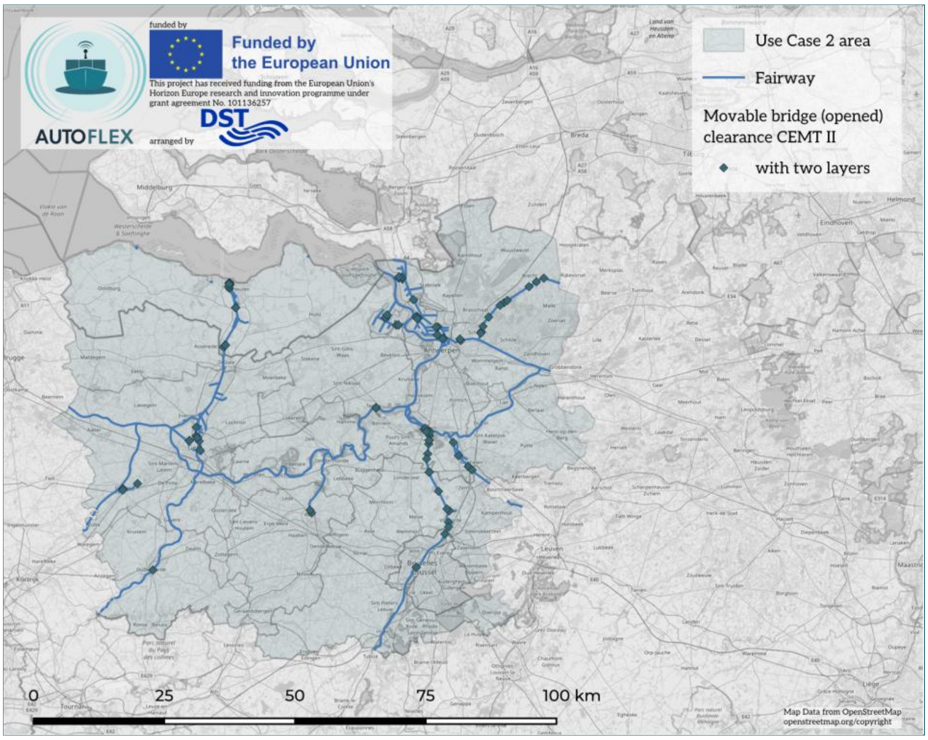

Figure 7-33: Clearance heights of the movable bridges (in opened state) on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class II vessel)[66]

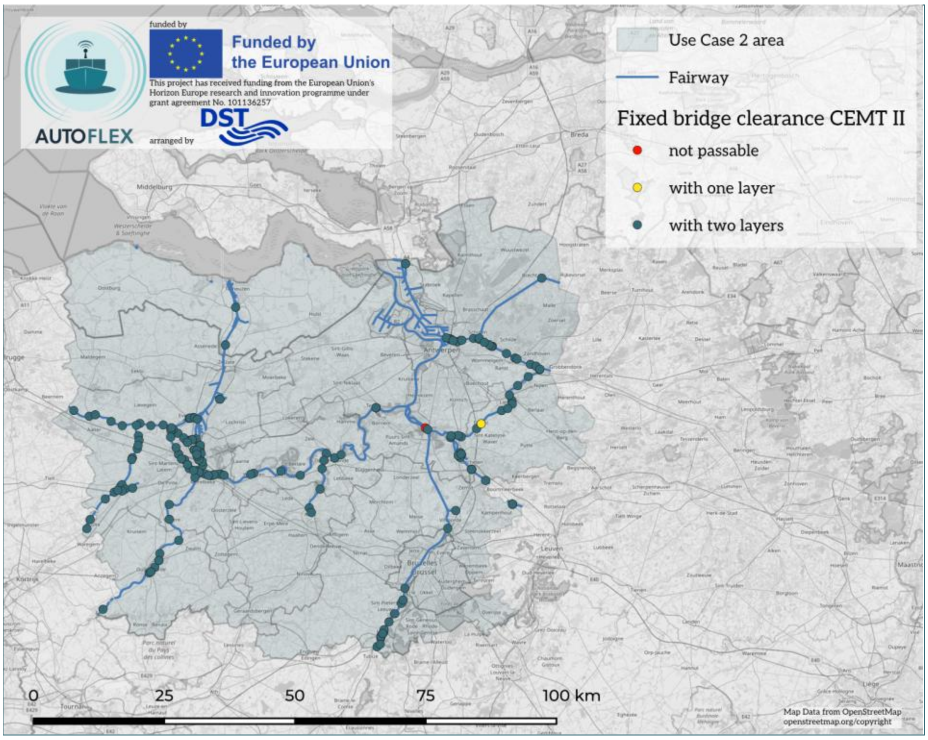

Figure 7-34: Clearance heights of the fixed bridges on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class II vessel)[67]

[66] Display per bridge opening; movable bridges are assumed as unoperated (closed)
[67] Display per bridge opening

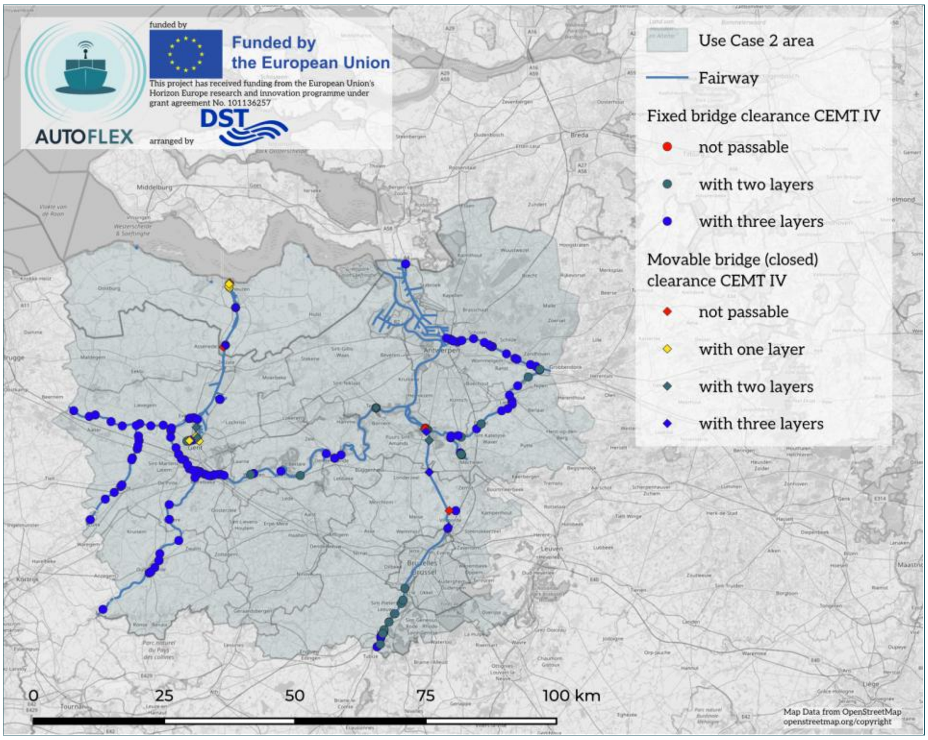

Figure 7-35: Clearance heights of all bridges on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class IV vessel)[68]

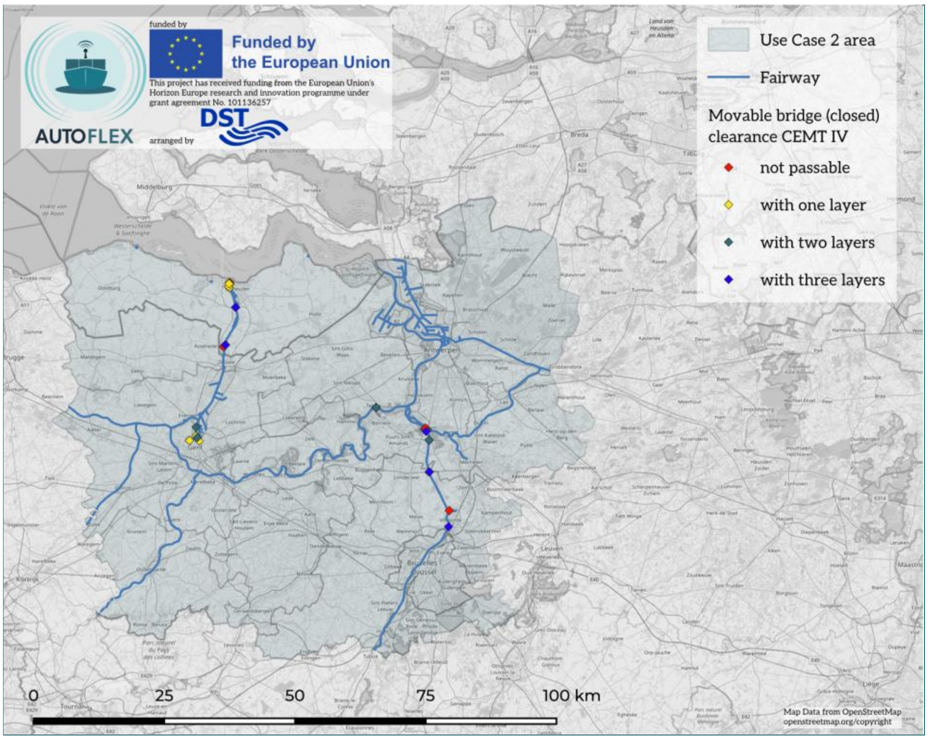

Figure 7-36: Clearance heights of the movable bridges (in closed state) on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class IV vessel)[69]

[68] Display per bridge opening; movable bridges are assumed as unoperated (closed)
[69] Display per bridge opening; movable bridges are assumed as unoperated (closed)

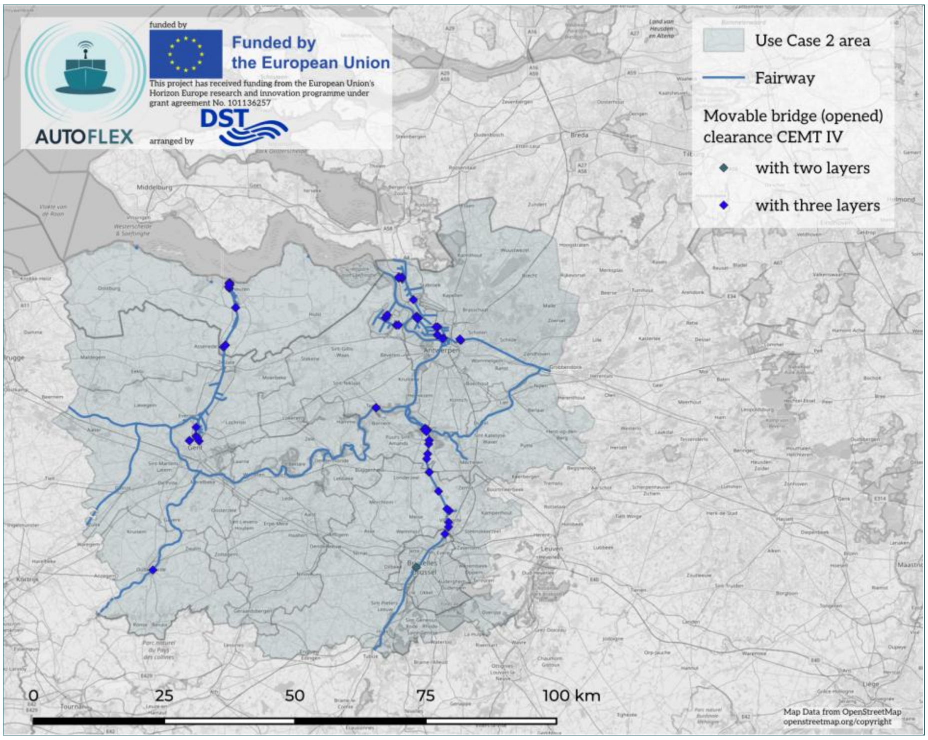

Figure 7-37: Clearance heights of the movable bridges (in opened state) on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class IV vessel)[70]

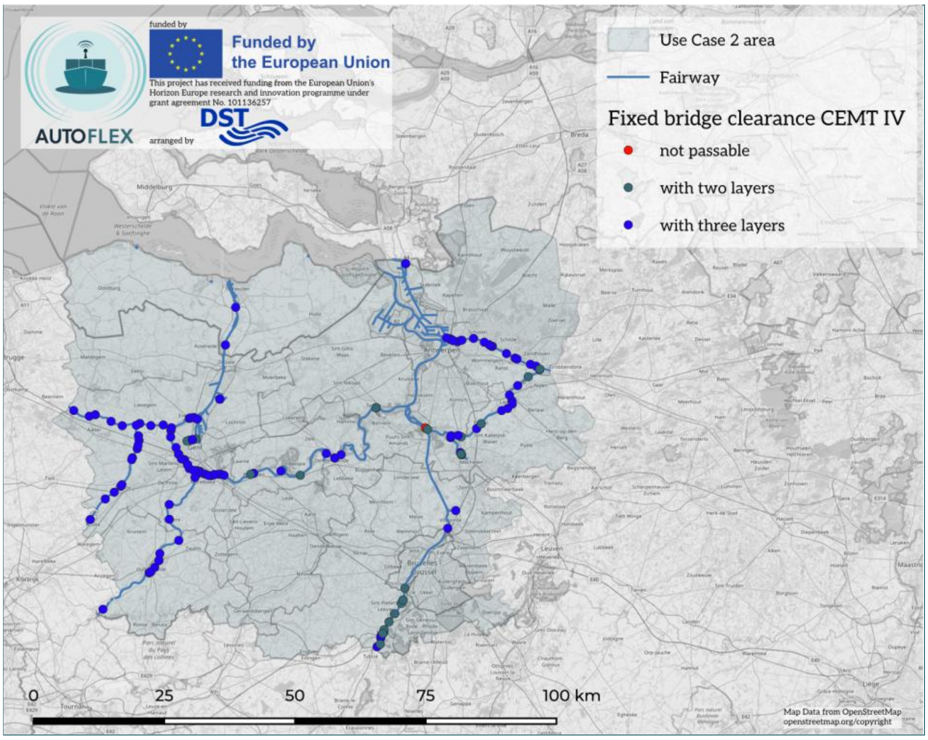

Figure 7-38: Clearance heights of the fixed bridges on the inland waterways in Use Case 2 area (for the AUTOFLEX CEMT class IV vessel)[71]

[70] Display per bridge opening; movable bridges are assumed as unoperated (closed)
[71] Display per bridge opening

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Apart from the spatial distribution of the bridge openings passable with no, one, two, or even three container layers on board, the statistical overview is of interest in this respect. The same picture is shown here again: The vast majority of bridge openings does not pose a problem to the passage of inland vessels whereas isolated bridges may need to be considered carefully when taken into account as part of a particular transport relation and the pertaining route.

The AUTOFLEX CEMT class II inland vessel can pass most of the bridge openings on inland waterways across all CEMT classes, with only single-digit numbers of possibly impassable bridge openings due to their missing height information (see Figure 7-39). Moreover, it becomes clear that bridge openings of movable bridges can generally be assumed as passable with the maximum number of layers, i. e., two layers.

The exact same picture emerges for the AUTOFLEX CEMT class IV inland vessel. As can be seen in Figure 7-40, only very few bridges throughout the considered geographic area feature no height information and, thus, could be impassable whereas the largest portion of the bridges is passable with two or even three container layers on board. Again, this can be explained with the greater bridge heights on the larger inland waterways this vessel type can sail on.

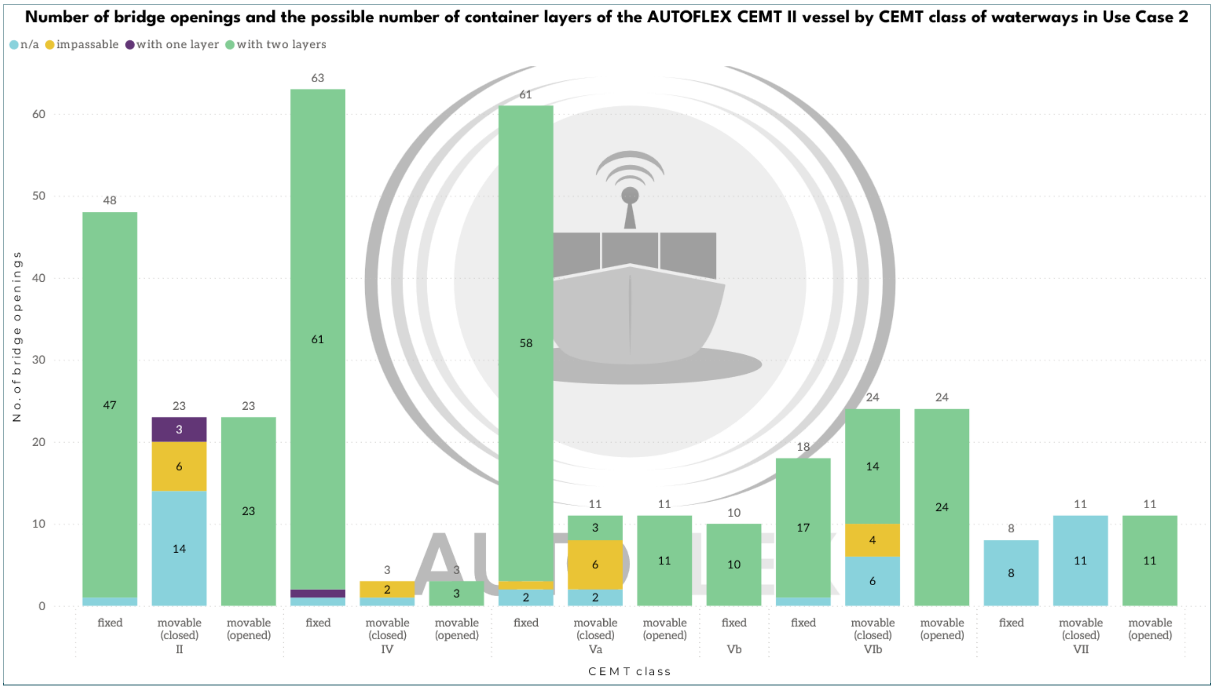

Figure 7-39: Number of bridge openings of fixed and movable bridges per CEMT class in the Use Case 2 area (passable for the AUTOFLEX CEMT II inland vessel)

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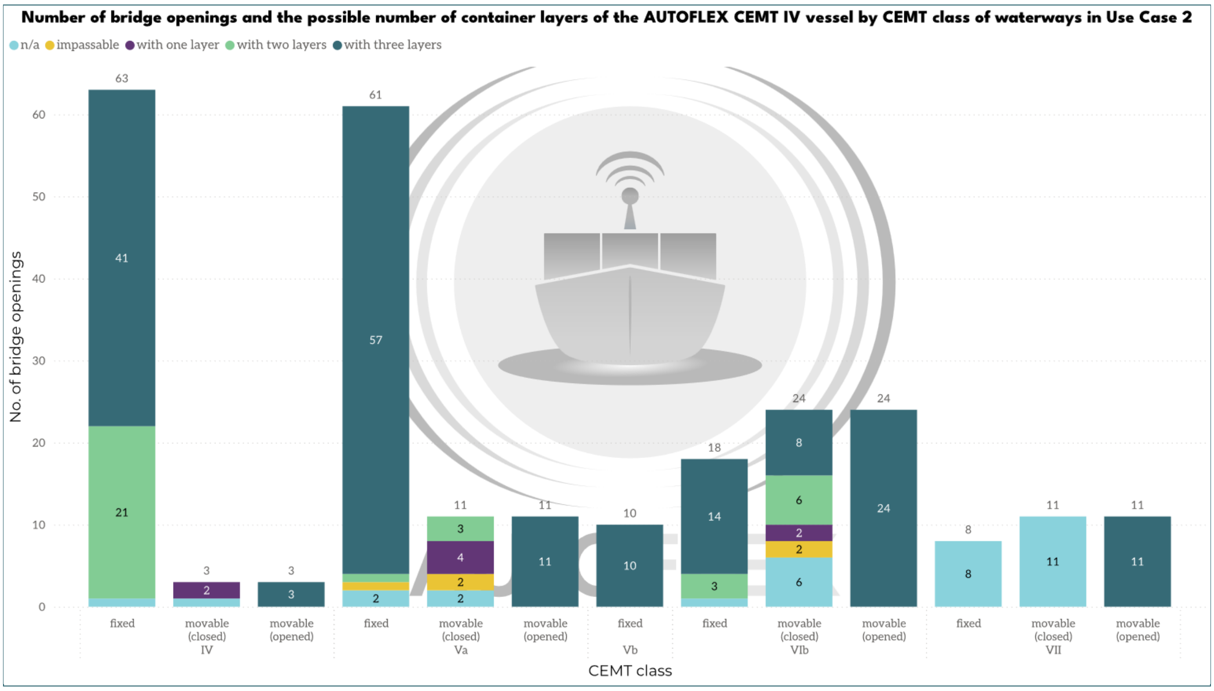

Figure 7-40: Number of bridge openings of fixed and movable bridges per CEMT class in the Use Case 2 area (passable for the AUTOFLEX CEMT IV inland vessel)

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8 ECONOMIC SETTING IN THE USE CASE AREAS

8.1 VOLUMES IN ROAD AND INLAND WATERWAY TRANSPORT

In order to exploit the full potential of the geographic and nautical analysis, the combination with an economic analysis is highly useful. As has been shown in numerous similar cases in the past, the parallel analysis of the supply and the demand sides leads to cross-fertilisation – particularly in the examination of new market segments for IWT (Alias et al., 2021; Alias et al., 2023; DST, 2013, 2022; Fiedler et al., 2023; Tangstad, Nordahl, Wennersberg, et al., 2023; van Hassel, 2011a, 2011b).

While the geographic and nautical analysis represents the supply side, the examination of a potential market and possible users stands for the demand side (Alias, Dahlke, et al., 2020; Alias, Gründer, et al., 2020). In the wake of the examinations presented above, the reasoning of the findings is to happen with (exemplary) representative cases in which the inland vessels to be designed are supposed to operate in and in which the envisioned transport system is destined for. By this, it can be safeguarded that both the inland vessels and the overarching transport system are suitable for the market conditions and infrastructural prerequisites of the service areas of the two use cases. Hence, a brief analysis of the economic setting is supposed to complement the geographic and nautical analysis and its findings presented above. However, this analysis is not to be confused with the profound market analysis, which is conducted as part of the task T2.2 entitled “Transport demand modelling (market analysis)” and documented as deliverable D2.2 “Market analysis” of the AUTOFLEX project (Küchle et al., 2024).

For the purpose, the region has been scrutinised in terms of transport volumes on domestic transport relations in Belgium and the Netherlands, respectively, and on cross-border relations between the two countries. Existing and publicly accessible data, particularly from the Eurostat, the Statistical Office of the European Union, has been used to collect and compile the data about the transport volumes within Belgium and the Netherlands, respectively, and cross-border transport between the two. As a reference year, the year 2023 has been used as the records were complete for that year (Eurostat, 2024e).

Figure 8-1 shows the volumes of containerised cargo in inland waterway transport in the Use Case 1 and Use Case 2 areas in the year 2023. While the volumes have not been published for some of the considered relations or did not feature any IWT volume, the majority of the transport relations provided a good impression of the waterborne transport business in the considered areas. With little surprise, both use case areas are dominated by the seaport hinterland traffic to the seaports of Rotterdam and Antwerp, respectively, whereas pure continental and domestic transport was rather the exception. Hence, it can be assumed that the largest part of the volume has been covered by larger inland vessels on inland waterways of higher CEMT classes. Within Use Case 1, the transport relations from and to the port of Rotterdam clearly dominate the scene, followed by relations from and to the port of Antwerp. Apart from those relations, waterborne transportation in the region is confined to the province of Zeeland (NUTS-2 region NL41), which is rooted in its geographic structure with its islands and peninsulas and in the fact that two large seaports, Vlissingen

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and Terneuzen, are situated there. Eventually, ten following transport relation have been identified as promising:

- NL33-NL41 (from the province Zuid-Holland to the province Zeeland)
- NL41-NL33 (from the province Zeeland to the province Zuid-Holland)
- NL32-NL33 (from the province Noord-Holland to the province Zuid-Holland)
- NL33-NL32 (from the province Zuid-Holland to the province Noord-Holland)
- NL33-NL33 (within the province Zuid-Holland)
- BE23-BE21 (from the province Oost-Vlaanderen to the province Antwerpen)
- BE21-BE23 (from the province Antwerpen to the province Oost-Vlaanderen)
- BE25-BE21 (from the province West-Vlaanderen to the province Antwerpen)
- BE21-BE25 (from the province Antwerpen to the province West-Vlaanderen)
- NL41-NL41 (within the province Zeeland)

2023	**Container load (IWT) in the Use Case 1 and Use Case 2 areas** (1,000 tons)									
load ↓ unload →	BE10	BE21	BE23	BE24	NL31	NL32	NL33	NL34	NL41	Total
BE10	-	-	-	-	-	-	-	-	-	-
BE21	-	35	268	-	12	620	856	288	62	2.079
BE23	-	335	-	-	-	-	33	1	4	369
BE24	-	-	-	-	-	-	-	-	-	-
NL31	-	5	-	-	-	-	220	-	-	225
NL32	-	248	-	-	1	2	1.685	-	5	1.936
NL33	-	2.048	41	-	200	1.379	1.335	541	2.328	5.544
NL34	-	850	-	-	-	-	395	7	1	1.252
NL41	-	102	14	-	-	4	2.106	-	147	2.226
Total	-	3.521	309	-	213	2.001	4.524	837	2.400	11.405

Figure 8-1: Volumes of containerised cargo in inland waterway transport in the Use Case 1 and Use Case 2 areas in 2023

Analogously, the volumes of road transport in the same region and in the same year have been examined. Figure 8-2 (as well as the Figure A-3 in the Appendix) shows the volumes of containerisable cargo in road transport in the Use Case 1 and Use Case 2 areas in the year 2023. The term 'containerisable cargo' refers to a selected set of cargo types according to the NST 2007 classification, which is a statistical classification of the goods transported by road, rail, inland waterway, and sea (maritime) transport and which groups the goods types into 20 main sectoral groups, including code numbers and item denominations (UNECE, 2024). The cargo types have been selected due to their current practice of transport in containerised form, i. e., containerised cargo, or their general suitability for that way of transport, i. e., containerisable cargo. Hence, the selected cargo types are prone to modal shift from road transport to inland waterway transport. Following the NST classification, the following cargo types have been identified as useful for further consideration:

- Textiles and textile products; leather and leather products (NST 05)
- Wood and products of wood and cork (except furniture); articles of straw and plaiting materials; pulp, paper and paper products; printed matter and recorded media (NST 06)
- Basic metals; fabricated metal products, except machinery and equipment (NST 10)

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- Machinery and equipment n.e.c.; office machinery and computers; electrical machinery and apparatus n.e.c.; radio, television and communication equipment and apparatus; medical, precision and optical instruments; watches and clocks (NST 11)
- Transport equipment (NST 12)
- Furniture; other manufactured goods n.e.c. (NST 13)
- Mail, parcels (NST 15)
- Equipment and material utilized in the transport of goods (NST 16)
- Goods moved in the course of household and office removals; baggage and articles accompanying travellers; motor vehicles being moved for repair; other non-market goods n.e.c. (NST 17)
- Grouped goods: a mixture of types of goods which are transported together (NST 18)
- Unidentifiable goods: goods which for any reason cannot be identified and therefore cannot be assigned to groups 01-16 (NST 19)
- Other goods n.e.c. (NST 20)

While the volumes were not available for domestic transports in Belgium, the numbers were consistently available for inner-Dutch transports and mostly for cross-border relations between the two countries as well (Eurostat, 2024c, 2024d). With the help of selected regions within the Use Case 1 and Use Case 2 areas, additional transport relations have been identified as potential cases of modal shift from road transport to inland waterway transport using the envisioned AUTOFLEX transport system and its small, flexible, automated, zero-emission inland vessels.

2023	Container load (road) in the Use Case 1 and Use Case 2 areas (tons)																				
load ↓ unload →	BE100	BE211	BE212	BE231	BE232	BE233	BE234	BE235	BE236	BE241	NL310	NL33A	NL332	NL333	NL337	NL33B	NL33C	NL324	NL329	NL411	Total
BE100	0	0	0	0	0	0	0	0	0	0	2.486	8.046	0	1.937	0	769	5.582	0	7.772	1.264	26.592
BE211	0	0	0	0	0	0	0	0	0	0	54.699	83.479	10.770	16.805	16.460	16.791	248.184	6.027	31.875	253.513	485.090
BE212	0	0	0	0	0	0	0	0	0	0	8.118	10.201	9.773	2.393	1.412	7.985	24.179	0	3.414	9.974	67.476
BE231	0	0	0	0	0	0	0	0	0	0	4.551	6.072	0	6.004	0	261	9.533	0	942	11.779	27.364
BE232	0	0	0	0	0	0	0	0	0	0	325	1.131	0	73	261	244	6.171	10	1.109	4.117	9.324
BE233	0	0	0	0	0	0	0	0	0	0	231	0	0	0	229	0	6.025	0	0	7.631	6.484
BE234	0	0	0	0	0	0	0	0	0	0	19.509	9.760	2.413	4.273	2.082	2.330	31.920	0	2.343	37.346	74.630
BE235	0	0	0	0	0	0	0	0	0	0	548	2.118	0	241	0	0	1.902	0	2.942	3.972	7.752
BE236	0	0	0	0	0	0	0	0	0	0	8.847	8.013	4.344	1.807	2.153	684	34.114	0	11.459	48.841	71.421
BE241	0	0	0	0	0	0	0	0	0	0	4.041	8.345	501	1.489	2.562	495	6.534	0	9.203	10.740	33.168
NL310	12.550	35.526	8.948	1.418	1.915	3.490	16.308	5.906	6.119	6.311	3.106.642	197.293	139.921	101.592	278.118	277.522	518.667	23.393	485.141	263.714	5.226.780
NL33A	431	38.074	3.858	3.816	8.807	98	19.217	233	11.115	4.568	130.581	955.307	32.895	36.844	85.648	91.588	826.957	3.489	77.893	187.684	2.331.419
NL332	511	1.087	707	142	0	0	40	145	227	1.873	94.478	35.808	670.335	239.087	96.404	82.035	440.884	2.190	102.685	100.470	1.768.638
NL333	4.501	4.016	3.885	625	29	0	7.845	0	1.955	135	56.904	26.070	69.707	723.470	108.194	64.974	713.816	857	237.625	111.224	2.024.607
NL337	12	5.742	519	327	712	0	2.103	0	1.024	3.760	94.885	20.773	135.630	81.926	610.892	426.963	227.889	45.599	303.143	90.708	1.961.900
NL33B	4.288	15.855	4.076	1.712	1.180	135	2.594	372	3.285	17.604	278.415	128.041	157.824	52.660	276.335	605.265	502.186	4.118	144.523	272.499	2.200.468
NL33C	31.250	237.407	25.972	2.923	6.037	2.726	18.313	3.635	46.698	27.964	640.239	639.666	554.981	1.071.187	257.835	585.062	9.244.808	11.631	597.860	1.384.484	14.006.190
NL324	0	12.089	0	0	0	0	0	0	0	0	6.430	2.481	3.855	863	8.176	1.194	5.026	63.386	143.103	8.557	246.602
NL329	0	17.306	638	3.492	45	0	12.494	184	3.980	14.559	339.864	62.796	106.331	245.463	463.838	158.404	465.074	198.638	3.923.315	274.617	6.016.421
NL411	15.318	263.951	25.077	3.989	3.189	8.392	63.793	3.421	36.025	25.365	418.734	369.727	69.576	154.685	220.505	135.923	1.302.806	32.380	181.960	3.585.252	3.334.815
Total	53.542	367.102	48.601	14.454	18.725	6.449	78.915	10.476	74.405	76.773	4.851.794	2.205.400	1.899.279	2.588.115	2.210.597	2.322.566	13.319.448	359.338	6.086.348	3.083.133	36.592.328

Figure 8-2: Volumes of containerisable cargo in road transport in the Use Case 1 and Use Case 2 areas in 2023

The final selection of the additional transport relations was arbitrary in nature. It has to be noted that the selected cases represent cases of potential use of the AUTOFLEX transport system only. Today, these transport relations are served by road transport. Given the geographic, nautical, and economic conditions, however, they appear promising cases for a potential modal shift in the future.

With the help of the two sets, i. e., the transport relations already employing inland waterway transport as well as the ones appearing appropriate for it, a set of representative routes through the area (based on a small economic analysis) has been identified in order to provide "typical" routes the AUTOFLEX vessels would need to be capable of sailing on. This shall neither be confused with the optimal routes between the two parties involved, typically a consignor, a consignee, or a seaport, nor with the economic assessment of most promising transport cases. They merely represent potential routes of the AUTOFLEX inland

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vessels in the Use Case 1 and Use Case 2 areas. By analysing more than a dozen routes and varying the inland vessel type, the number of container layers, the origin and destination, and the use case area, a sufficient level of heterogeneity is aspired – which again provides a good base for an effective design of both the inland vessels and the overarching transport system tailored to the conditions of the two use case areas.

Apart from the volumes of road and inland waterway transport in the considered geographic areas, their economic structure and particularly the local enterprises representing potential consignors and consignees, respectively, have been analysed. For that, different enterprise databases have been tapped. The Structural Business Statistics database issued by the European Statistical Office (Eurostat), which describe the structure, main characteristics, and performance of economic activities in the European Union, has been used for the analysis of the economic activity in the considered geographic areas (Eurostat, 2024f).

Eventually, the local units, i. e., enterprises located in the considered geographic area or parts of those, e. g., a workshop, a factory, a warehouse, or an office, and the persons employed in these local units have been examined. The different units are categorized into different types of economic activity according to the NACE classification, which is a statistical classification of the economic activity in the European Union and encompasses four levels from the economic area over the economic activity and the domain activity to the business line (Eurostat, 2008). Within that classification, a focus has been laid on the sectors manufacturing (section C) and wholesale and retail trade (section G) as both are inclined to container transport and, thus, appear as potential candidates for the use of the envisioned AUTOFLEX transport system.

Moreover, the ORBIS database, which contains company data from all over the world and is frequently used for economic studies, and the Amadeus dataset with information on European enterprises in particular including their financial and business details have been used. The database has been consulted for the identification of potential consignors and consignees, respectively, which are candidate users of the envisioned AUTOFLEX transport system.

With the help of the above-mentioned database, the theoretical scenarios are built around real-world enterprises from the above-mentioned economic areas and sending or receiving the above-mentioned cargo categories. By focusing on the Use Case 1 and Use Case 2 areas and those geographic areas therein with high transport intensity with respect to inland waterway transport as well as with promising modal shift potential, realistic consignors could be identified. Next, these were included in several theoretical scenarios each with two locations (of companies or seaports) in the same use case area in order to generate a continental transport relation between a (potential) consignor and a (potential) consignee or between a seaport and an enterprise in an export case or import case, respectively. The resulting transport relations were used as examples in the geographical and nautical analysis (see section 9).

Another interesting aspect is the consideration of additional logistics nodes with a sufficient volume of consignments entering and leaving. A 'distribution centre' (DC) is used as a collective term and represents different types of logistics nodes, such as warehouses, freight hubs, e-fulfilment centres, logistics depots, city hubs, or distribution centres in the narrower sense (Nefs, 2022). Onstein et al. (2021) have analysed different types of distribution centres

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in the Netherlands, including parcel lockers and pick-up points, city hubs, parcel and postal sorting facilities, regional food wholesale and retail facilities, national retail and e-commerce facilities, manufacturer DC facilities, bulk facilities, and global agricultural auctions, with respect to their number, size and location. The related geo-dataset is publicly available and has been used for a comparison of the network of small inland waterways in the Use Case 1 area with the precise location of the DCs, more precisely logistics buildings larger than 500 square metres and the pertaining plots. Figure 8-3 shows the locations of the DCs with the entire inland waterway network whereas Figure 8-4 exhibits the small inland waterways only. Figure 8-5 adds the locations of the container and general cargo terminals along with all inland waterways of the Use Case 1 area, while Figure 8-6 presents the same matter with the network of small inland waterways.

Concerning the geographic distribution of the DCs, it is clearly evident that most locations of large DCs are directly on the waterway or in close vicinity to it. On the contrary, the largest accumulations of terminals are situated around the big metropolitan areas and along the larger inland waterway network whereas the region within the ring, which mostly features inland waterways of CEMT classes II and III, there are only a few terminals. Consequently, it can be assumed that a large portion of the incoming and outgoing transport of consignments of these DCs takes place with the help of trucks. Moreover, the locations appear appropriate for a modal shift towards inland waterways, albeit subject to detailed consideration in individual cases.

The analysis could not be conducted in the same depth for the Use Case 2 area as data availability forms a problem. Although openly accessible geo-data about enterprises or logistics premises in Belgium were not available, the existing literature has provided some guidance to the selection process of potential locations for an exemplary examination of the geographic and nautical conditions of the AUTOFLEX inland vessels to be designed (Adam et al., 2021).

The potential locations of Stow & Charge hubs, temporary port terminals, and mobile distribution centres will be further examined in the respective work streams, i. e., in tasks T3.1 ("Combined energy and cargo hubs (Stow & Charge)"), T3.2 ("Temporary Port Terminals"), and T3.3 ("Mobile Distribution Centres") within WP 3 ("Developing automated multimodal zero-emission Transport Systems") of the AUTOFLEX project. For that purpose, the work presented in this report will act as a starting point, and the collected data as a reference for the development of concepts and solutions in the above-mentioned tasks.

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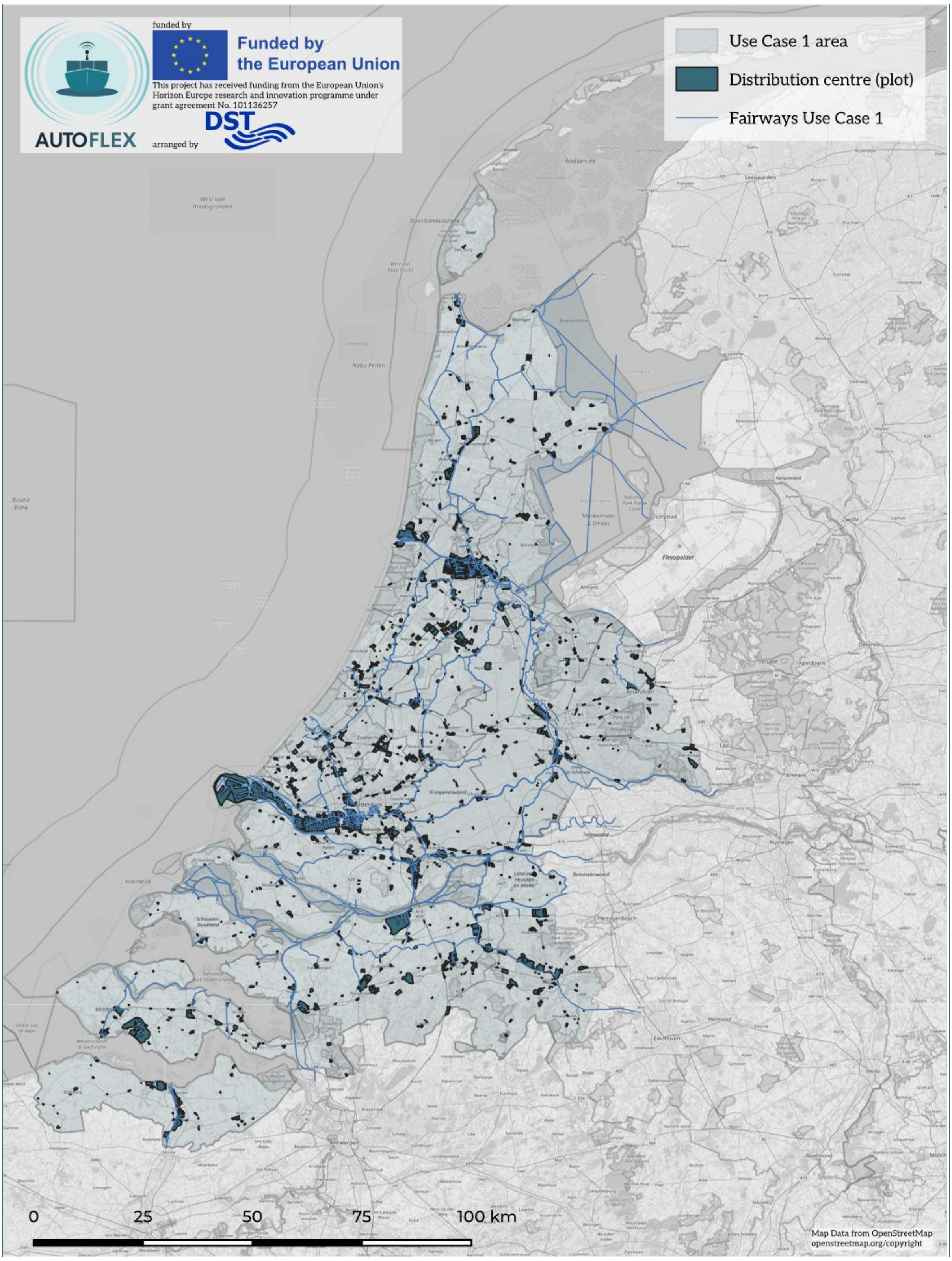

Figure 8-3: Distribution centres and inland waterways in the Use Case 1 area

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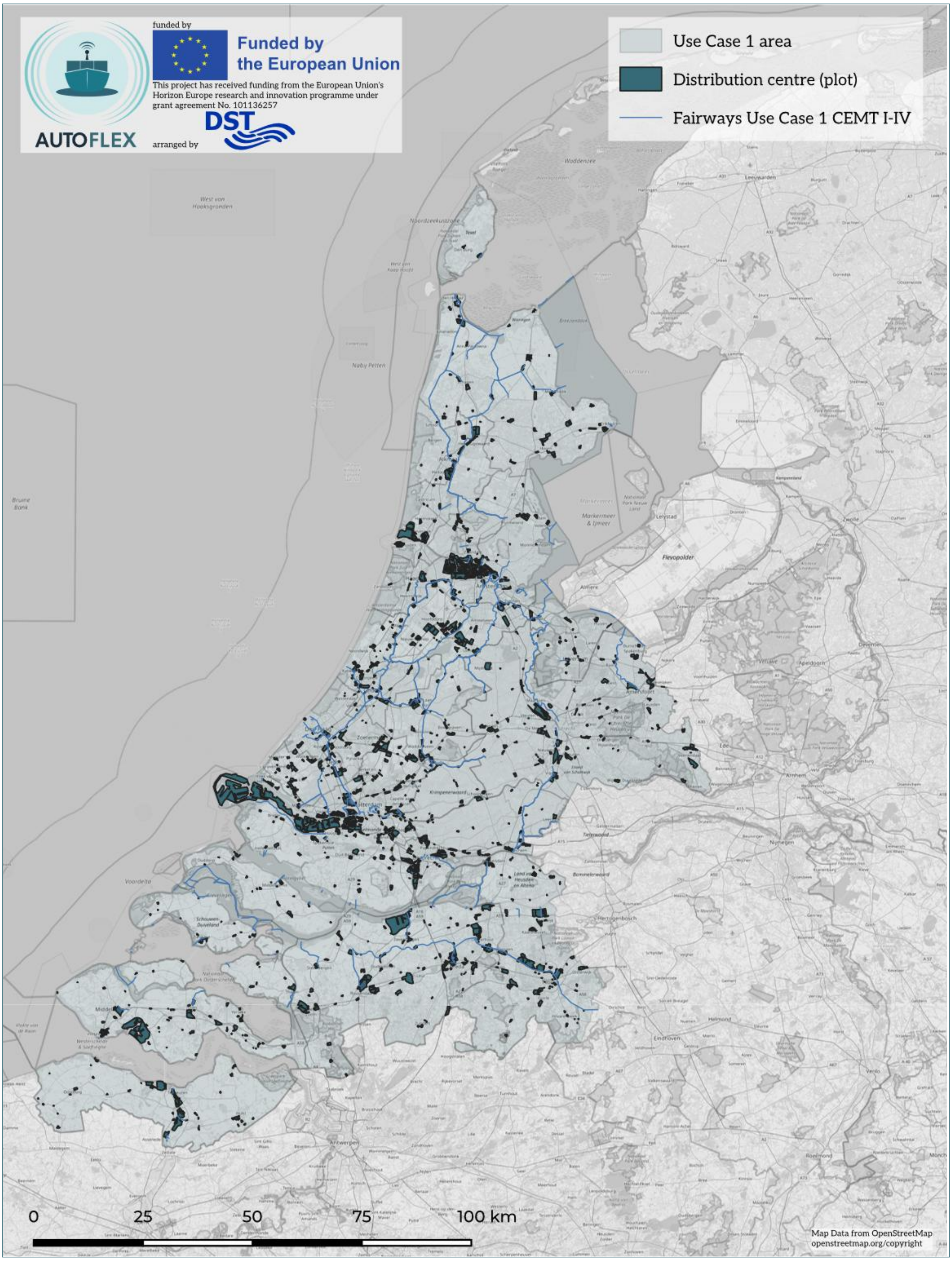

Figure 8-4: Distribution centres and small inland waterways in the Use Case 1 area

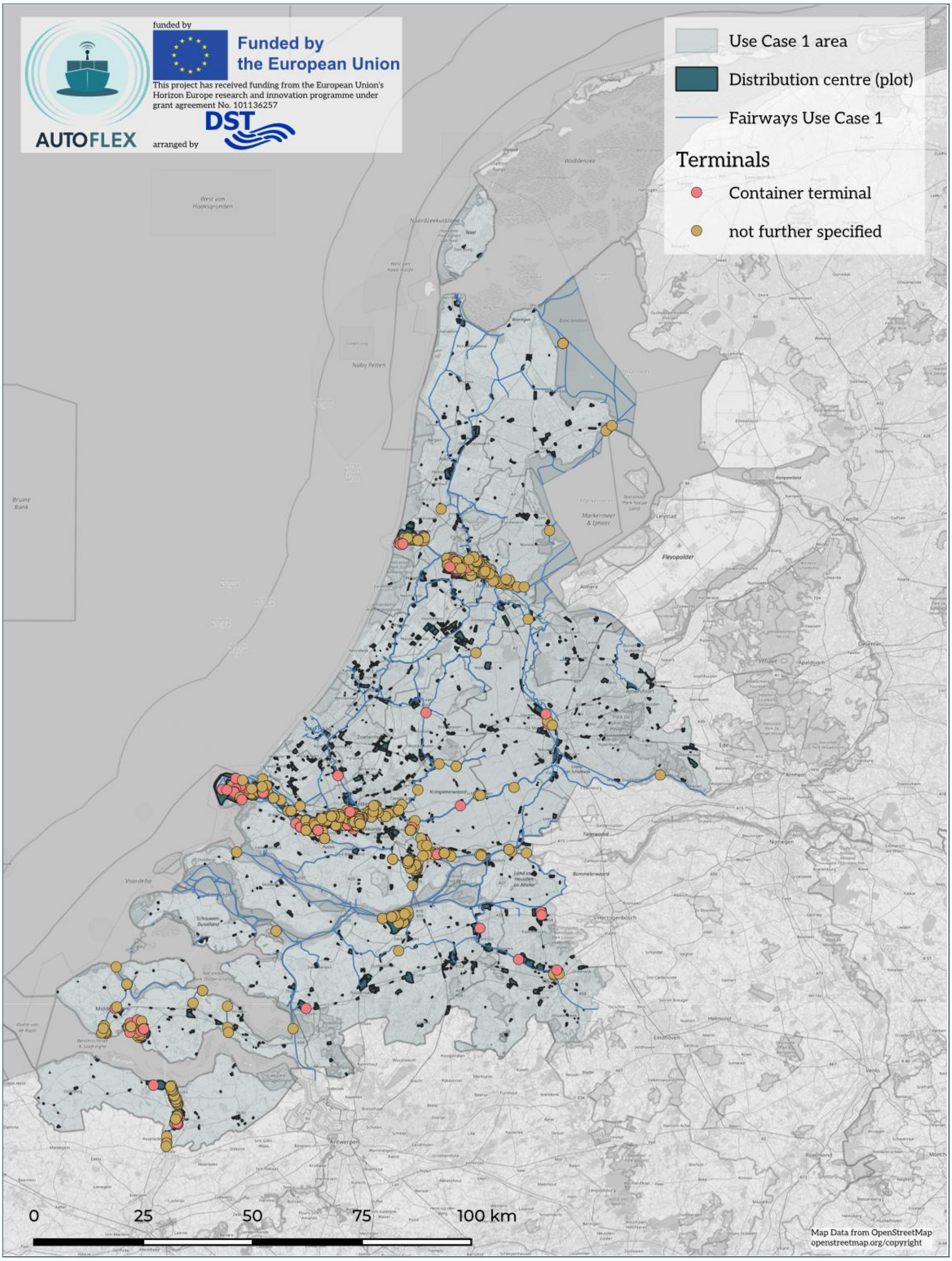

Figure 8-5: Distribution centres, inland waterways, and inland terminals in the Use Case 1 area

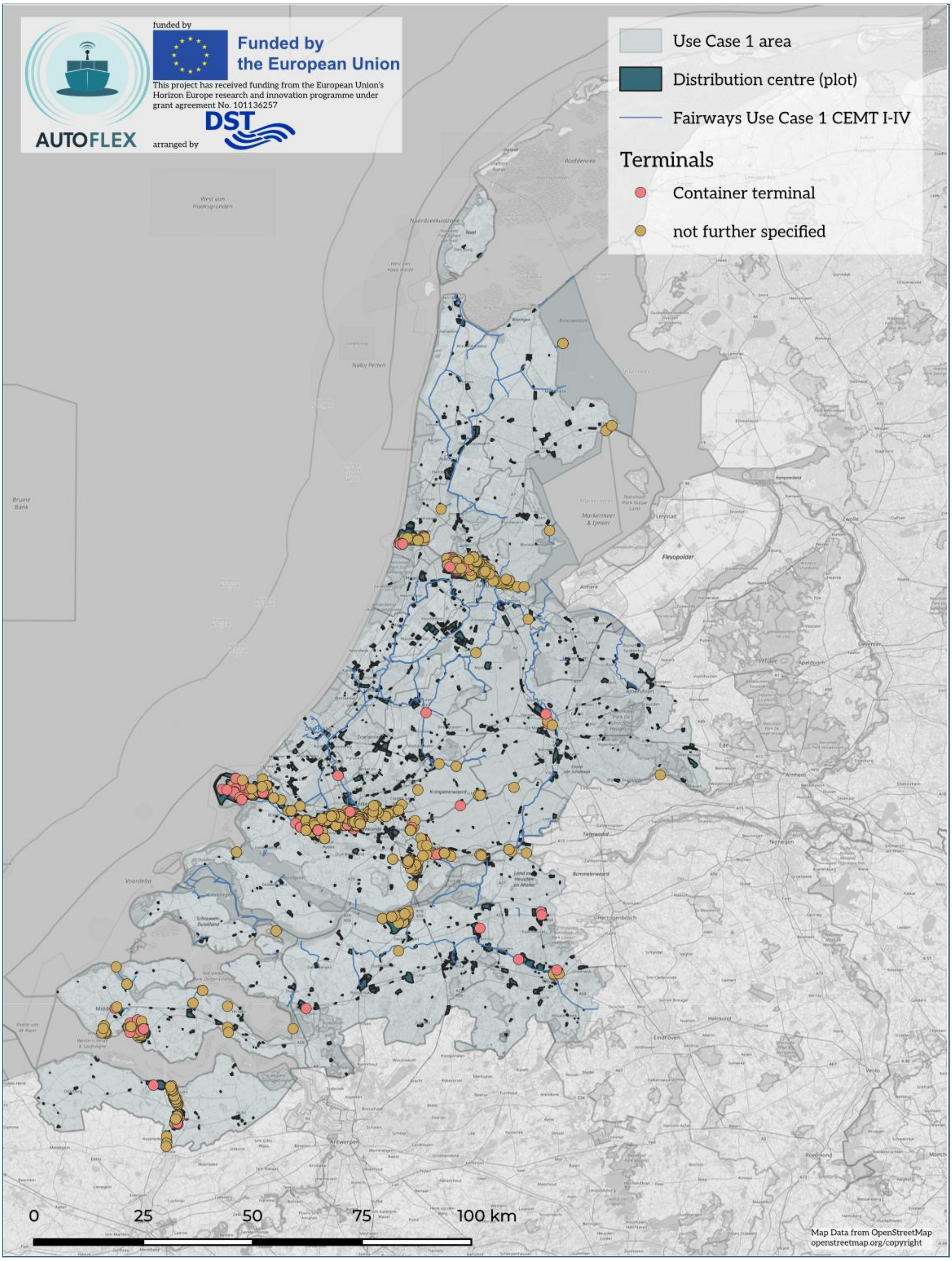

Figure 8-6: Distribution centres, small inland waterways, and inland terminals in the Use Case 1 area

8.2 EXISTING WATERBORNE TRANSPORT SERVICES AND ROUTES

The landscape of existing waterborne transport services in the considered geographic region has been researched with the help of a plethora of sources. These included several statistical publications and databases, public information portals, and openly accessible scientific publications. Moreover, information has been retrieved from the service profiles and portfolios of logistics service providers operating in the considered use case areas as well as from several expert interviews conducted with various stakeholders, including inland shipping companies, freight forwarders, ports and terminals, road transport companies, and consignors. A part of the information collection process has been documented in the AUTOFLEX deliverable D2.2 “Market analysis” (Küchle et al., 2024).

A glance at the inland waterway map reveals three corridors connecting Amsterdam and Ijmuiden in the north to Rotterdam and Hoek van Holland in the South: a westerly corridor (along Den Haag and Leiden), a middle corridor passing through Alphen aan den Rijn, and an easterly corridor leading through Utrecht. The traffic density on the corridors are sufficiently high, although with different levels of utilisation and congestion. Some parts of the considered network are heavily busy with inland waterway transport along the Rhine-Alpine Corridor or from and to the port of Amsterdam while others are regularly service, albeit with less services and a lower number of vessels. While the outer ring with an inland waterway corridor of CEMT class VI appears to be the heavily busy part, the residual corridors with the lower CEMT classes remain less utilised (but not underutilised or unused).

The expert interviews as well as the statistical data yielded that several inland waterway services with fixed routes in the use case areas are already in place. However, the existing transports are oftentimes sold on the spot market rather than transformed into regular liner service concepts (which still do exist on the market though). This can be interpreted in different ways: either the spot market can be served in the future with the AUTOFLEX transport system and the newly developed inland container vessels, on which individual slots can be booked, or the market volume for such novel transport services using small and automated vessels has not been sufficiently high in the past.

Table 8-1 shows a number of existing waterborne transport services in the Use Case 1 area. The major terminals are integrated into larger liner services along the larger inland waterways. Fleet and terminal operators like CCT[72], CTU[73], CTV[74], HTS[75], IDT[76], MCS[77], MCT[78], NWL[79], OTB[80], TMA[81], and WML[82] offer miscellaneous connections to the seaports of Rotterdam and Antwerp as well as industrial sites and inland terminals in the Netherlands and neighbouring countries via the larger inland waterways on the outer ring of the geographic area considered in the AUTOFLEX project.

72 Moerdijk Combined Cargo Terminals BV
73 Container Terminal Utrecht bv (now part of TMA Multimodal BV)
74 CT Vrede-Steinweg B.V.
75 HTS Intermodaal B.V.
76 Ijssel Delta Terminal (Ijdt) B.V.
77 Multimodal Container Services BV
78 MCT Lucassen B.V.
79 NWL Norddeutsche Wasserweg Logistik GmbH
80 Op- En Overslag Terminal Bergambacht (Otb) B.V
81 TMA Logistics BV
82 Westerman Multimodal Logistics B.V.

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Figure 8-7 and Figure 8-8 present the existing service routes with the entire inland waterway network of the Use Case 1 area and with the small inland waterways only, respectively. A comparison of the Table 8-1 and the two maps shows that there is already transport business activity on the stretches of the larger CEMT classes V and VI whereas transport services on the smaller inland waterways have not been deployed on a regular basis. Consequently, there is hardly an overlap between the existing routes and the small inland waterways of the CEMT classes I to IV. Accordingly, the distribution of terminals is denser along the inland waterway corridors of higher CEMT classes.

Apart from one route from Alphen aan den Rijn in the vicinity of a multinational brewing company to the large seaports, the residual existing routes lead over a CEMT class VI inland waterway on the outer ring. Given the small inland waterways described in section 5.6.1 and the few inland terminals described in section 5.6.2, it is worth investigating the potential of a waterborne transport system using small, flexible, automated, zero-emission inland vessels. Although the locations of the plots with distribution centres as shown in Figure 8-3 are in close vicinity of the smaller inland waterways, hardly any inland (container) terminals are available along those.

In order to ensure the usability of the inland vessels in the envisioned use case areas and their compliance with the geographic and nautical conditions there, a series of representative transport relations have been identified in order to distil the major information about the route and its waypoints – which are then supposed to serve a guideline for the design processes of the novel inland vessels and the AUTOFLEX transport system. These representative transport relations presented in detail in the subsequent section 9.

Table 8-1: Existing waterborne transport services in the Use Case 1 area

No.	Route name	Origin	Destination	Time and distance	Type and operator(s)	Freq.
1	West-Brabant Corridor: ECT	Hutchison Ports ECT Delta (Rotterdam)	Moerdijk Container Terminals	6 h; 61 km	IWT: BTT[83], CCT, OCT[84]	18 /week
2	Moerdijk – Alphen	Moerdijk Container Terminals	Alpherium (Alphen a.d.R.)	6 h; 63 km	IWT: CCT	14 /week
3	Rotterdam – Alphen	United Waalhaven Terminals (Rotterdam)	Alpherium (Alphen a.d.R.)	6 h; 45 km	IWT: CCT	7 /week
4	Rotterdam - Amsterdam	Barge Center Waalhaven (Rotterdam)	TMA Terminal Amsterdam	8 h; 119 km	IWT: MCT Lucassen	7 /week

[83] BTT Multimodal Container Solutions B.V.
[84] Oosterhout Container Terminal B.V.

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5	North West Central Corridor: Rotterdam – Hasselt	TMA Terminal Amsterdam	Barge Center Waalhaven (Rotterdam)	6 h; 119 km	IWT: WML	7 /week
6	Ensemble Utrecht-Tiel-Rotterdam	CTU Utrecht	Hutchison Ports ECT Euromax (Rotterdam)	8 h; 99 km	IWT: CTU	3 /week
7	Amsterdam – Rotterdam (Euromax)	Hutchison Ports ECT Euromax (Rotterdam)	TMA Terminal Amsterdam	12 h; 149 km	IWT: TMA Logistics	2 /week
8	Amsterdam – Rotterdam (ECT Delta)	Hutchison Ports ECT Delta (Rotterdam)	TMA Terminal Amsterdam	12 h; 148 km	IWT: TMA Logistics	2 /week
9	TMA - APM2	APMT Maasvlakte II (Rotterdam)	TMA Terminal Velsen (Ijmuiden)	12 h; 162 km	IWT: TMA Logistics	2 /week
10	TMA - Kramer delta	TMA Terminal Amsterdam	Kramer Delta (Rotterdam)	12 h; 152 km	IWT: TMA Logistics	2 /week
11	Import en Export	CTU Flevokust Lelystad	Barge Center Waalhaven (Rotterdam)	2.5 d; 153 km	IWT: CTU	2 /week
12	Amsterdam - Ireland (DC AMS) SB	Rotterdam Shortsea Terminals	TMA Terminal Amsterdam	8 h; 149 km	SSS: Samskip	1 /week
13	NOVUM	Barge Center Waalhaven (Rotterdam)	CT Vrede Amsterdam	10 h; 118 km	IWT: CTV	1 /week
14	Rotterdam - Venlo Barge	Mainport Container Services - City Depot	Moerdijk Container Terminals	8 h; 48 km	IWT: HutchisonPortsEuIn	1 /week

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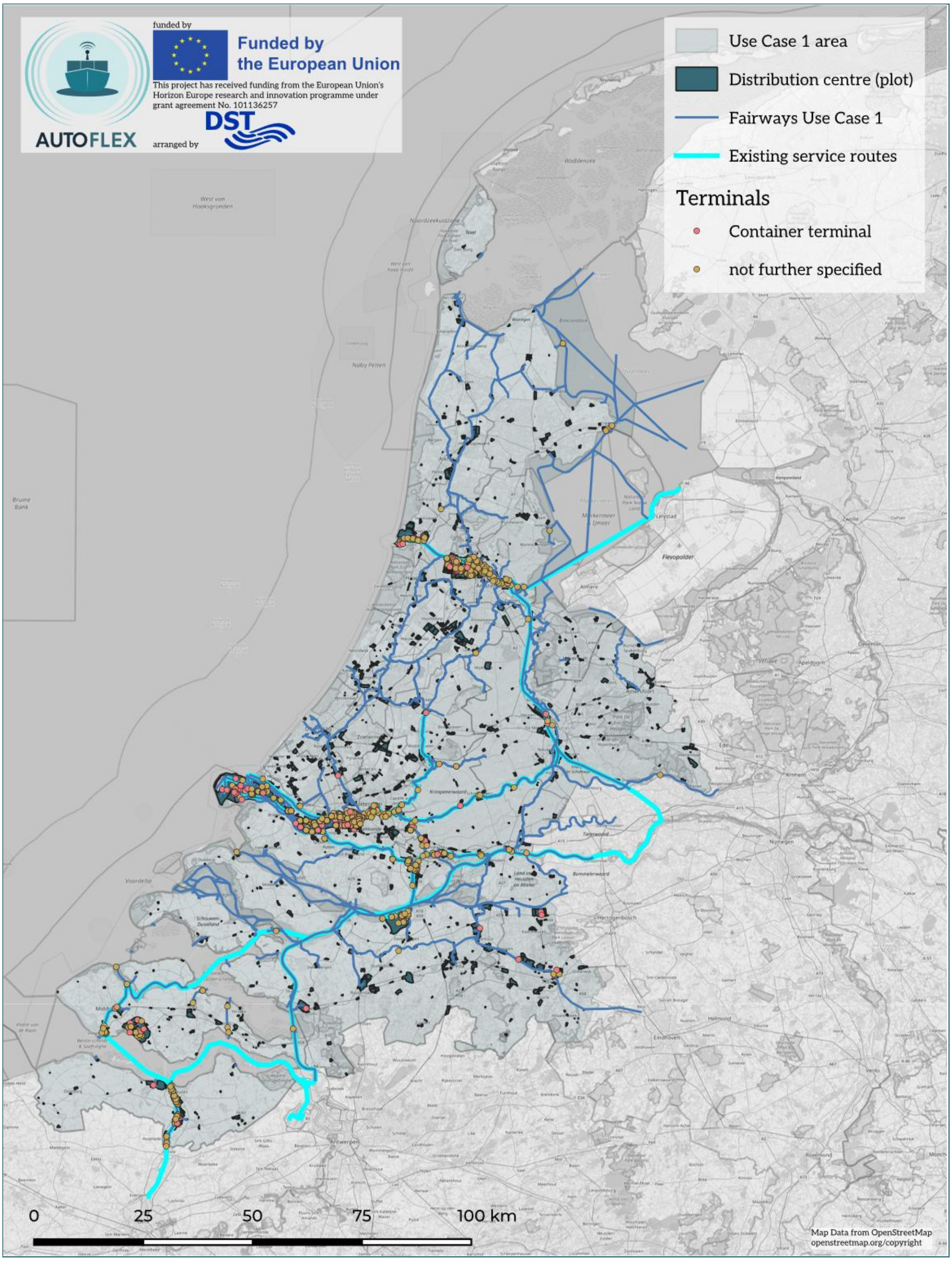

Figure 8-7: Existing waterborne transport services in the Use Case 1 area

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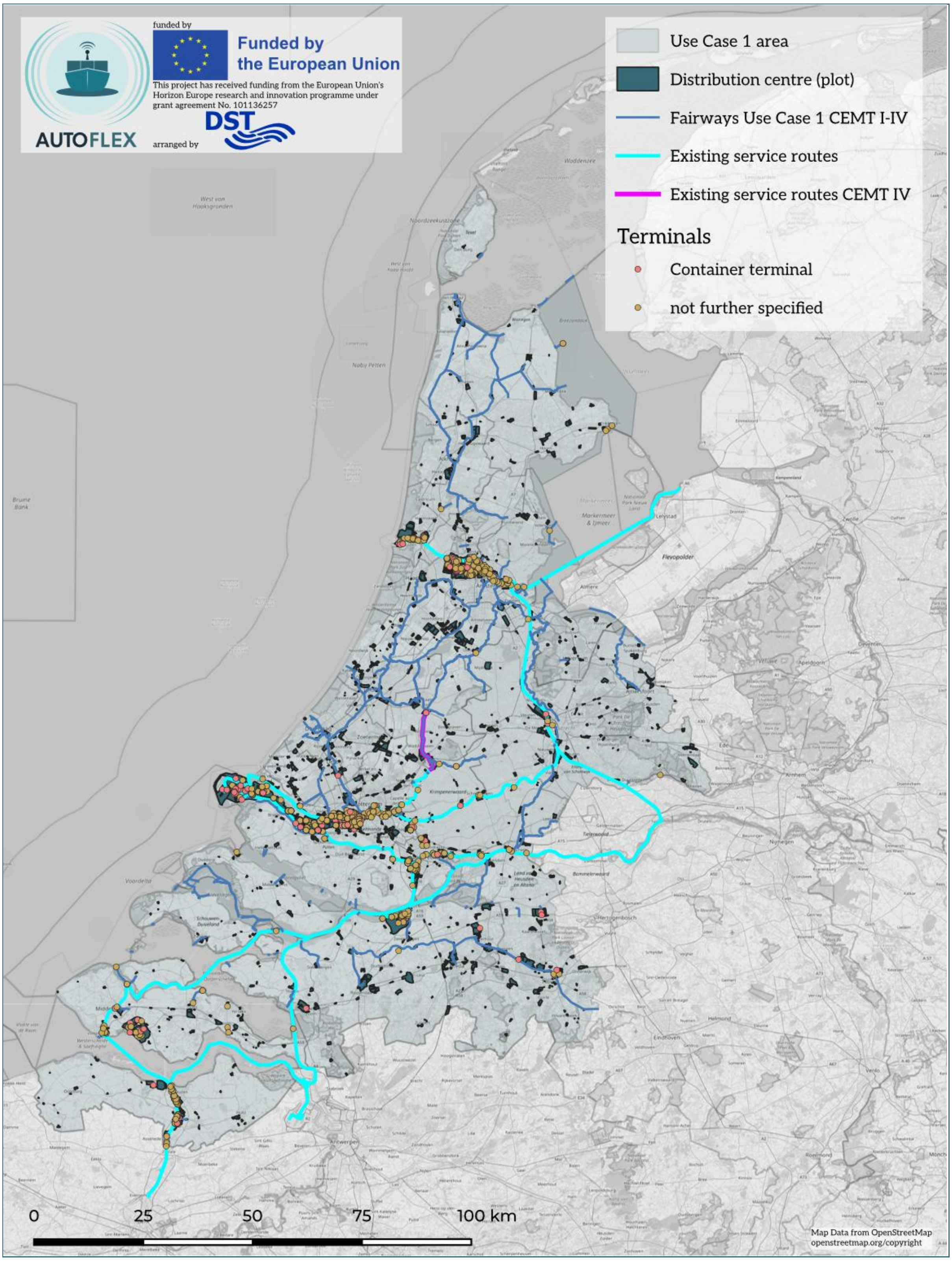

Figure 8-8: Existing waterborne transport services on small inland waterways in the Use Case 1 area

9 EXEMPLARY TRANSPORT ITINERARIES

In the following, a series of exemplary transport cases with the pertaining transport routes and residual information about the envisioned waterborne transport service have been compiled into a travel itinerary with the major geographic and nautical information about each of the routes. By this, it becomes evident how the information compiled in this task of the AUTOFLEX project can be utilised in a sensible manner throughout the course of the research project (and even beyond).

While the selection of origin and destination of each case is derived from the above-mentioned analysis (see section 8.1), the AUTOFLEX inland vessel type and the number of container layers are arbitrarily selected. Also, the precise consignor and consignee are chosen in a manual process based on the transport relations deemed promising from the transport economic analysis of the road- and waterborne freight transport activities in the considered use case areas. As the real enterprises underlying the cases have not been approached by the authors of this report, the routes represent potential cases only, albeit realistic in terms of modal shift potential and likelihood of waterborne transport services.

The goal of the selection has not necessarily been to achieve optimality regarding routing but the realism in terms of realisability which again depends on the economic viability as well as geographic and nautical feasibility of the new waterborne transport service. The selected transport cases comprise useful and feasible examples of using the AUTOFLEX inland vessel for typical transport relations in the considered geographic region.

In the following, a total of 14 different transport relations (and 17 different variants) have been scrutinised by means of the EuRIS travel planner. For each transport relation, the ISRS codes of the origin and destination terminals and the vessel- and cargo-related details are fed into the search mask in order to obtain the route information of the respective relation (see Figure 9-1).

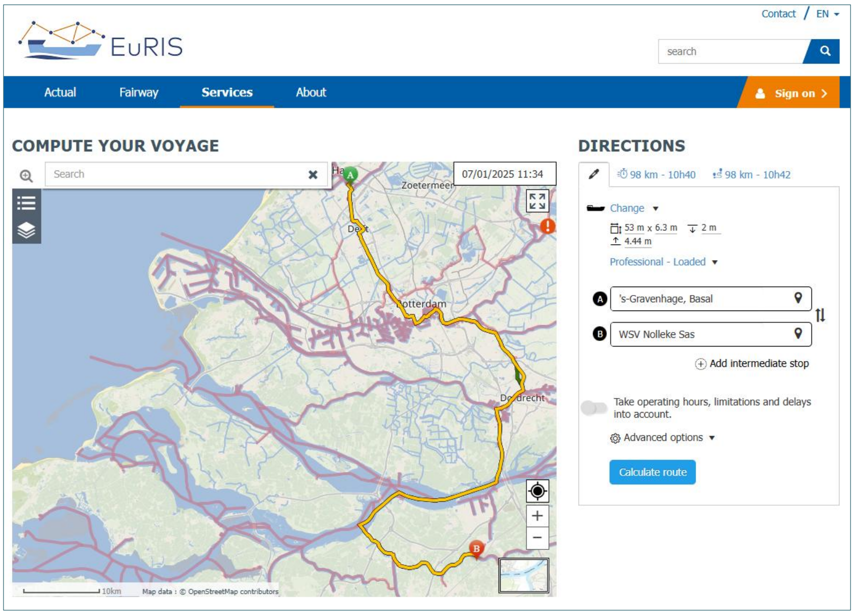

Figure 9-1: Screenshot of the search entry mask of the EuRIS travel planner

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9.1 TRANSPORT ROUTE 1: DEN HAAG – OUDENBOSCH

The first travel route connects a consignor from Den Haag in the NUTS-2 region NL33 (Zuid-Holland) with a consignee from Oudenbosch in the region NL41 (Noord-Brabant). An AUTOFLEX CEMT class II inland vessel is assumed to be used with one container layer on board. Figure 9-2 shows the route while Table 9-1 presents the travel itinerary.

As the information retrieved from the EuRIS travel planner may exhibit erroneous and missing data as has been mentioned earlier (see section 1.2), a manual check of the transport route has confirmed the transport distance (of the IWT leg) of 98.07 kilometres, revealed the passage of three locks and 40 bridges, and exhibited a travel time of 14 hours and 49 minutes, resulting in an average travel speed of 12.67 kilometres per hour. It has to be noted though that the actual travel time may differ (partly even grossly) as the EuRIS travel planner takes the operational readiness of the items to be passed, such as bridges and locks, at the stated times of departure and arrival of the requested voyage into account. Table A-4 in the Appendix shows a travel itinerary of transport route no. 1 extended by manually retrieved information about the route. Table A-5 in the Appendix lists all bridges and locks to be passed on that very route.

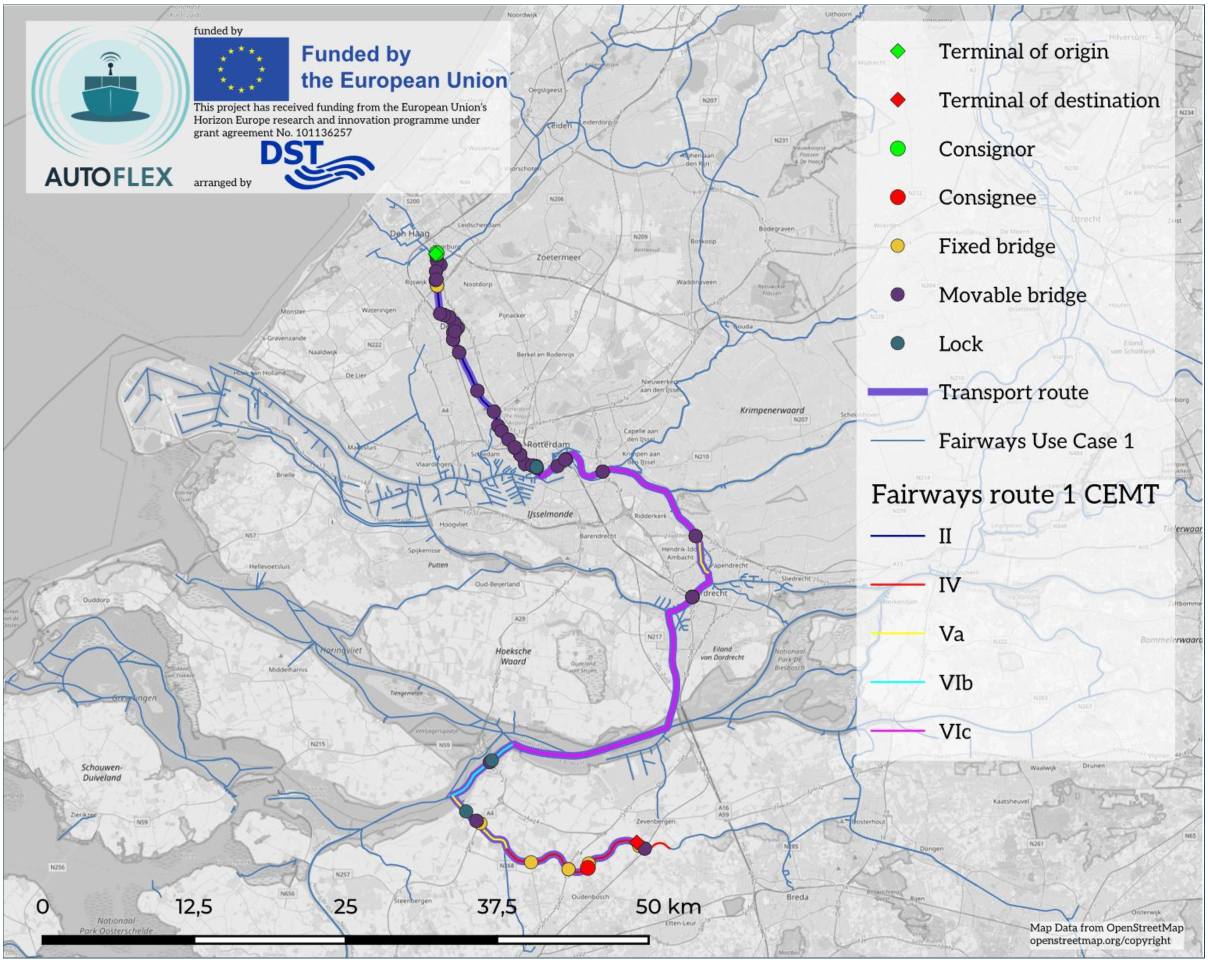

Figure 9-2: Exemplary transport route no. 1 from Den Haag to Oudenbosch

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Table 9-1: Travel itinerary of transport route no. 1 from Den Haag to Oudenbosch

Transport route no. 1 from Den Haag to Oudenbosch	
Name of consignor (origin)	Provider of industrial equipment
Pre-haul distance to terminal of origin (road)	0.9 km
Name of consignee (destination)	Machines and components for the food industry
Post-haul distance from terminal of destination (road)	6.7 km
Name of terminal of origin*	's-Gravenhage, Basal
ISRS of terminal of origin*	NLHAG1250A0HAG200005
Type of terminal of origin*	Bulk terminal
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker : n/a
Name of terminal of destination*	WSV Nolleke Sas
ISRS of terminal of destination*	NLHON0012600HON00189
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker : false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	II, IV, V a, VI b, VI c
Number of locks passed*	3
Total distance travelled*	98.07 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL1250A00000	II	36.51	False	5.0	5.0
NL0125000036	II	343.58	False	7.0	7.0
NL0201B00000	II	810.74	False	7.0	7.0
NL0020103105	II	1426.79	False	7.0	7.0
NL0020103247	II	2656.96	False	7.0	7.0
NL0020103513	II	2728.63	False	7.0	7.0
NL0020103786	II	886.41	False	7.0	7.0
NL0020103875	II	6753.43	False	7.0	7.0
NL0201T00000	II	968.15	False	7.0	7.0
NL0020104670	II	717.26	False	7.0	7.0
NL0020104742	II	225.02	False	7.0	7.0
NL0020104764	II	208.99	False	7.0	7.0
NL0020104785	II	216.57	False	7.0	7.0

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NL0020104807	II	254.29	False	7.0	7.0
NL0020104832	II	121.09	False	7.0	7.0
NL0020104845	II	2229.86	False	7.0	7.0
NL0020105068	II	101.05	False	7.0	7.0
NL0020105078	II	978.49	False	7.0	7.0
NL0020105175	II	879.77	False	7.0	7.0
NL0010201299	VIc	93.95	True	17.0	17.0
NL0010201213	VIc	854.44	True	13.0	13.0
NL0010201195	VIc	181.3	True	13.0	13.0
NL0010201155	VIc	404.37	True	13.0	13.0
NL0102C00122	VIc	640.56	True	13.0	13.0
NL0102C00101	VIc	216.5	True	13.0	13.0
NL0102C00000	VIc	1013.16	True	13.0	13.0
NL0010200793	VIc	1639.79	True	13.0	13.0
NL0010200733	VIc	603.66	True	17.0	17.0
NL0010200543	VIc	1897.72	True	17.0	17.0
NL0010200533	VIc	97.75	True	17.0	17.0
NL0010200499	VIc	345.65	True	17.0	17.0
NL0010200484	VIc	147.95	True	17.0	17.0
NL0010200349	VIc	1349.28	True	17.0	17.0
NL0010200308	VIc	409.1	True	17.0	17.0
NL0010200000	VIc	3085.88	True	17.0	17.0
NL0010112476	VIc	1662.4	True	17.0	17.0
NL0010112244	VIc	2326.65	True	17.0	17.0
NL0010112125	VIc	1190.03	True	17.0	17.0
NL0101C00000	Va	2613.26	True	12.0	12.0
NL0010111768	VIc	818.05	True	17.0	17.0
NL0011100000	VIc	103.9	True	13.0	13.0
NL0011100010	VIc	170.88	True	13.0	13.0
NL0011100027	VIc	743.13	True	13.0	13.0
NL0011100101	VIc	205.97	True	13.0	13.0
NL0011100122	VIc	62.25	True	13.0	13.0
NL0011100128	VIc	404.59	True	13.0	13.0
NL0011100169	VIc	1044.72	True	13.0	13.0
NL0011100273	VIc	582.53	True	13.0	13.0
NL0011100331	VIc	405.26	True	13.0	13.0
NL0011100372	VIc	78.01	True	13.0	13.0
NL0011100380	VIc	519.96	True	13.0	13.0
NL0011200881	VIc	918.26	True	17.0	17.0
NL0011200776	VIc	1055.57	True	17.0	17.0

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NL0011200521	VIc	2549.48	True	17.0	17.0
NL0011200070	VIc	4511.21	True	17.0	17.0
NL0011200000	VIc	701.81	True	17.0	17.0
NL0010802387	VIc	8484.11	True	17.0	17.0
NL0010803235	VIc	3899.55	True	17.0	17.0
NL0010803625	VIc	401.29	True	17.0	17.0
NL0010803665	VIc	454.69	True	17.0	17.0
NL0014300000	VIb	476.63	True	17.0	17.0
NL0014300047	VIb	3347.78	False	17.0	17.0
NL0014300382	VIb	415.04	False	17.0	17.0
NL0014300424	VIb	2513.26	False	17.0	17.0
NL0012603806	Va	716.89	False	12.0	12.0
NL0012603786	Va	194.68	False	12.0	12.0
NL0012603223	Va	5632.58	False	10.0	10.0
NL0012603124	IV	986.76	False	10.0	10.0
NL0012602777	IV	3479.35	False	10.0	10.0
NL0012602468	IV	3084.42	False	10.0	10.0
NL0012601885	IV	5829.41	False	8.0	8.0
NL0012601584	IV	0.0	False	8.0	8.0

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9.2 TRANSPORT ROUTE 2: ROOSENDAAL – ROTTERDAM

The second travel route connects a consignor from Roosendaal in the NUTS-2 region NL41 (Noord-Brabant) with the seaport in Rotterdam (in the province Zuid-Holland, NL33). An AUTOFLEX CEMT class IV inland vessel is assumed to be used with one container layer on board. Figure 9-3 shows the corresponding route while Table 9-2 presents the travel itinerary.

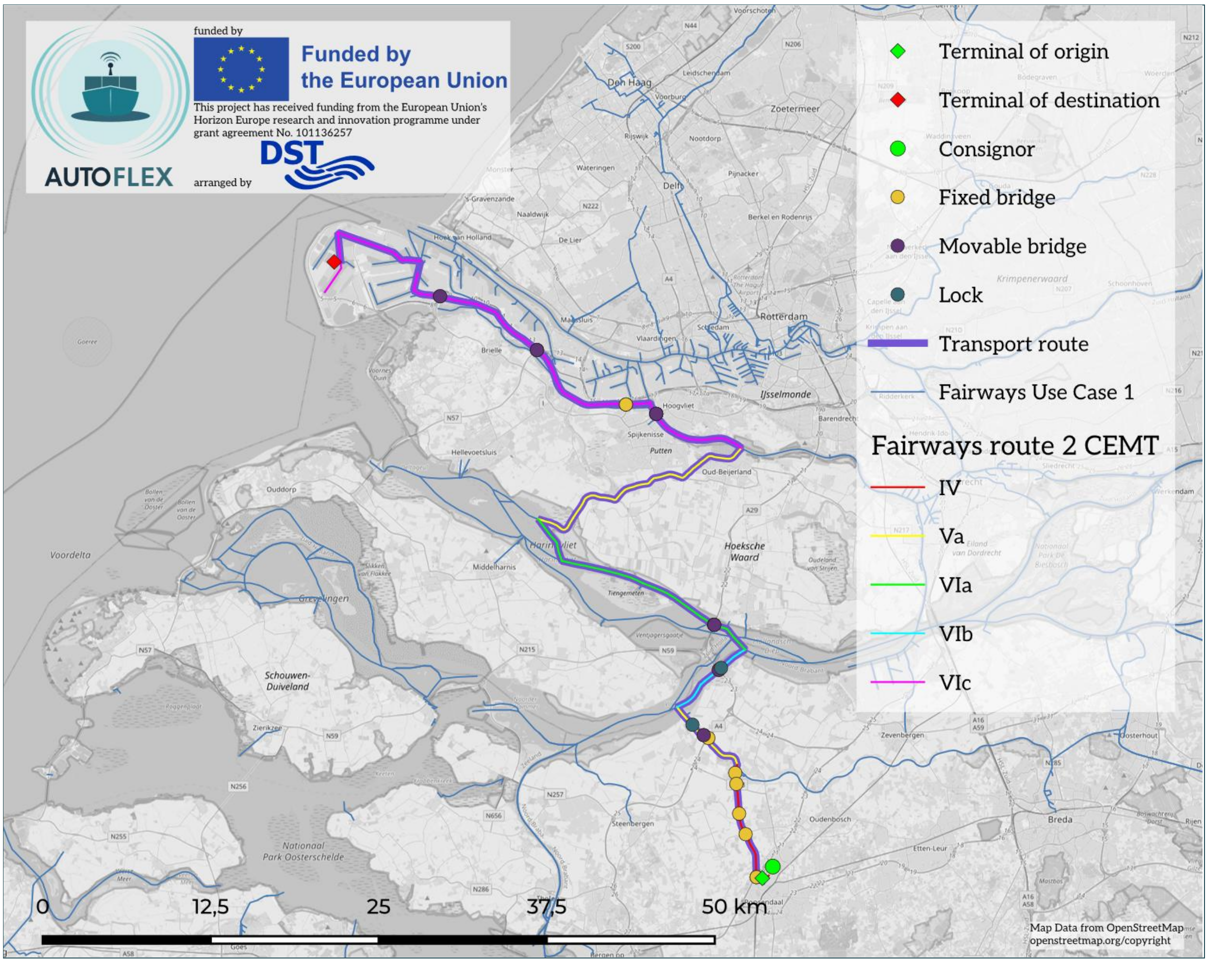

Figure 9-3: Exemplary transport route no. 2 from Roosendaal to Rotterdam

Table 9-2: Travel itinerary of transport route no. 2 from Roosendaal to Rotterdam

Transport route no. 2 from Roosendaal to Rotterdam	
Name of consignor (origin)	Manufacturer of plastics
Pre-haul distance to terminal of origin (road)	1.6 km
Name of seaport (destination)	Port of Rotterdam
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	WUBBEN
ISRS of terminal of origin*	NLROO0086200WUB00011
Type of terminal of origin*	Bulk terminal

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Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	RWG - ROTTERDAM WORLD GATEWAY
ISRS of terminal of destination*	NLRTM0126200RWG00014
Type of terminal of destination*	Container terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	IV, V a, VI a, VI b, VI c
Number of locks passed*	2
Total distance travelled*	102.22 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL0086200000	IV	396.89	False	9.0	9.0
NL0126D00130	IV	4960.26	False	10.0	10.0
NL0126D00626	IV	3916.18	False	10.0	10.0
NL0012603223	Va	5632.58	False	10.0	10.0
NL0012603786	Va	194.68	False	12.0	12.0
NL0012603806	Va	716.89	False	12.0	12.0
NL0014300424	VIb	2513.26	False	17.0	17.0
NL0014300382	VIb	415.04	False	17.0	17.0
NL0014300047	VIb	3347.78	False	17.0	17.0
NL0014300000	VIb	476.63	True	17.0	17.0
NL0011700000	VIa	1276.05	True	17.0	17.0
NL0011700127	VIa	848.94	True	17.0	17.0
NL0011700212	VIa	927.8	True	17.0	17.0
NL0011700305	VIa	316.55	True	17.0	17.0
NL0011700337	VIa	191.73	True	17.0	17.0
NL0011700356	VIa	5670.67	True	17.0	17.0
NL0011700923	VIa	6281.42	True	17.0	17.0
NL0117B00000	VIa	3646.36	True	17.0	17.0
NL0011300330	Va	3264.58	True	12.0	12.0
NL0011300656	Va	14969.69	True	12.0	12.0
NL0011101936	VIc	6985.15	True	13.0	13.0
NL0011102634	VIc	912.77	True	13.0	13.0
NL0011102726	VIc	323.84	True	13.0	13.0

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NL0011500000	VIc	827.87	True	13.0	13.0
NL0011500082	VIc	1674.35	True	13.0	13.0
NL0011500250	VIc	5245.38	True	13.0	13.0
NL0011500774	VIc	354.92	True	17.0	17.0
NL0011500810	VIc	1034.41	True	17.0	17.0
NL0011500913	VIc	7017.11	True	17.0	17.0
NL0011501615	VIc	4269.61	True	17.0	17.0
NL0011502042	VIc	111.36	True	5.0	5.0
NL0116A00383	VIc	440.52	True	17.0	17.0
NL0116A00278	VIc	1053.14	True	17.0	17.0
NL0116A00252	VIc	257.83	True	17.0	17.0
NL0116A00159	VIc	931.63	True	17.0	17.0
NL0115600000	VIc	365.32	True	5.0	5.0
NL0115600036	VIc	1024.12	True	9.0	9.0
NL0126000000	VIc	5234.63	True	9.0	9.0
NL0126500000	VIc	2193.2	True	9.0	9.0
NL0126200000	VIc	1319.55	True	9.0	9.0

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9.3 TRANSPORT ROUTE 3: ZAANDAM – ROTTERDAM

The third travel route connects a consignor from Zaandam in the NUTS-2 region NL32 (Noord-Holland) with the seaport in Rotterdam (in the province Zuid-Holland, NL33). An AUTOFLEX CEMT class II inland vessel is assumed to be used with one container layer on board. Figure 9-4 shows the corresponding route while Table 9-3 presents the travel itinerary.

The same transport relation can also be served with an AUTOFLEX CEMT class IV inland vessel carrying three container layers. Figure 9-5 and Table 9-4 illustrate the respective route and travel itinerary.

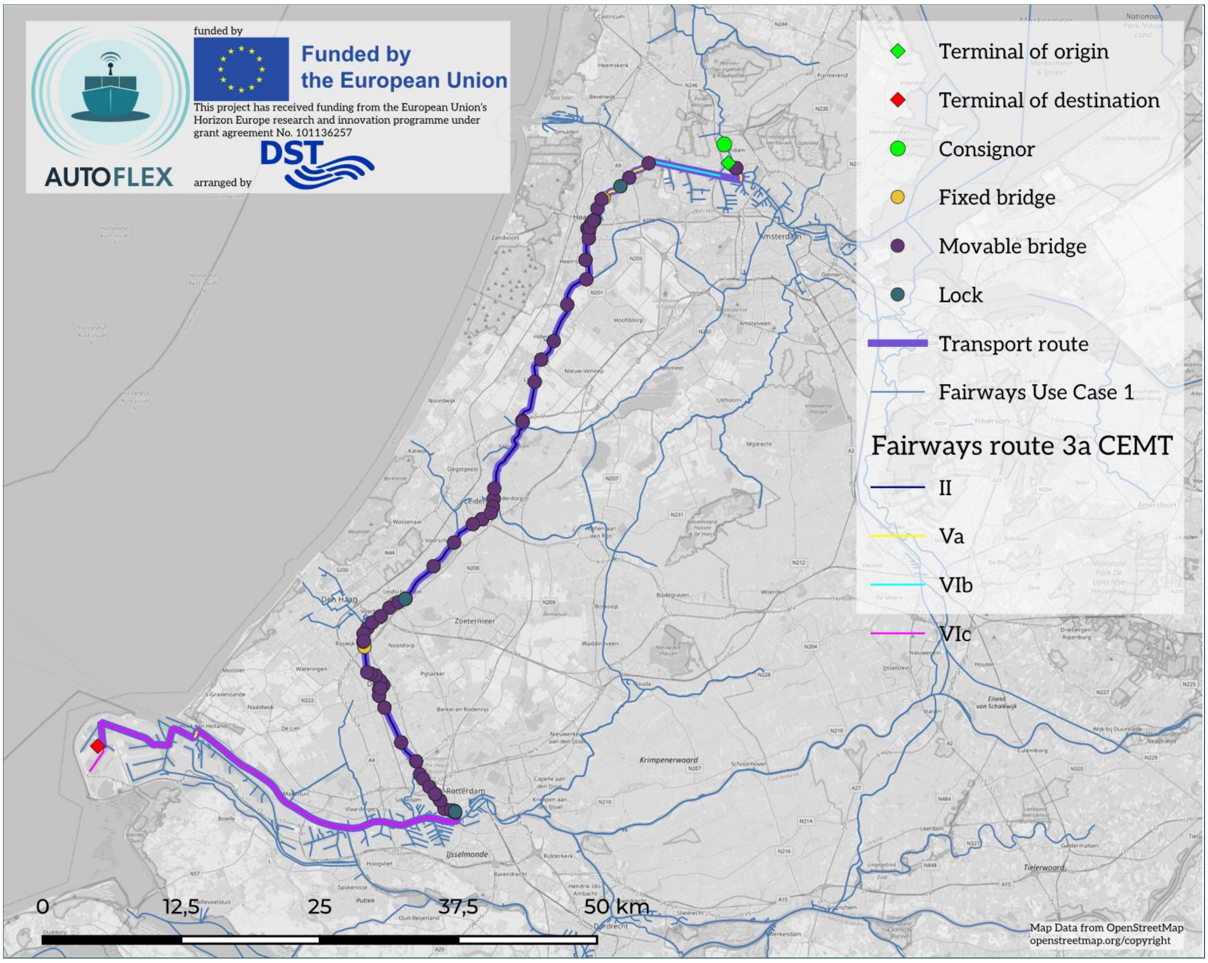

Figure 9-4: Exemplary transport route no. 3a from Zaandam to Rotterdam

Table 9-3: Travel itinerary of transport route no. 3a from Zaandam to Rotterdam

Transport route no. 3a from Zaandam to Rotterdam	
Name of consignor (origin)	Baked goods manufacturer
Pre-haul distance to terminal of origin (road)	2.7 km
Name of consignee (destination)	Port of Rotterdam
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Zaandam, OUDE HAVEN STEIGER 1

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ISRS of terminal of origin*	NLZAA01015ZGOH100004
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	RWG - ROTTERDAM WORLD GATEWAY
ISRS of terminal of destination*	NLRTM0126200RWG00014
Type of terminal of destination*	Container terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	II, V a, VI b, VI c
Number of locks passed*	3
Total distance travelled*	128.05 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0101500000	Va	437.66	False	12.0	12.0
NL0023600108	Va	525.43	False	12.0	12.0
NL0023600042	Va	655.84	False	12.0	12.0
NL0023600029	Va	133.53	False	12.0	12.0
NL0023600000	Va	290.4	False	12.0	12.0
NL0023301419	VIb	1963.47	False	17.0	17.0
NL0023301376	VIb	427.71	False	17.0	17.0
NL0023301217	VIb	1594.14	False	17.0	17.0
NL0023301118	VIb	986.03	False	17.0	17.0
NL0023300987	VIb	1308.37	False	17.0	17.0
NL0023300961	VIb	264.62	False	17.0	17.0
NL0023300788	VIb	1732.78	False	17.0	17.0
NL0020200000	Va	3795.65	False	12.0	12.0
NL0020200379	Va	542.9	False	12.0	12.0
NL0020200433	Va	3203.19	False	12.0	12.0
NL0020200754	Va	477.99	False	12.0	12.0
NL0020200801	Va	157.17	False	7.0	7.0
NL0020200817	II	1278.62	False	7.0	7.0
NL0020200945	II	2965.2	False	7.0	7.0
NL0020201242	II	1618.29	False	7.0	7.0
NL0020201403	II	101.46	False	7.0	7.0

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NL0020201413	II	7299.21	False	7.0	7.0
NL0020202143	II	2018.62	False	7.0	7.0
NL0020202345	II	2552.55	False	7.0	7.0
NL0020202600	II	4048.5	False	7.0	7.0
NL0020100628	II	506.68	False	7.0	7.0
NL0020100678	II	168.97	False	7.0	7.0
NL0020100695	II	218.63	False	7.0	7.0
NL0020100717	II	655.09	False	7.0	7.0
NL0020100783	II	218.73	False	7.0	7.0
NL0020100805	II	218.41	False	7.0	7.0
NL0020100826	II	145.81	False	7.0	7.0
NL0020100841	II	145.79	False	7.0	7.0
NL0020100856	II	402.07	False	7.0	7.0
NL0020100896	II	519.08	False	7.0	7.0
NL0020100948	II	136.24	False	7.0	7.0
NL0020100961	II	548.59	False	7.0	7.0
NL0020101016	II	475.14	False	7.0	7.0
NL0020101064	II	3515.28	False	7.0	7.0
NL0020101415	II	551.83	False	7.0	7.0
NL0020101470	II	736.41	False	7.0	7.0
NL0020101544	II	2035.4	False	7.0	7.0
NL0020101748	II	1281.0	False	7.0	7.0
NL0020101876	II	1109.94	False	7.0	7.0
NL0020101987	II	11182.04	False	7.0	7.0
NL0020103105	II	1426.79	False	7.0	7.0
NL0020103247	II	2656.96	False	7.0	7.0
NL0020103513	II	2728.63	False	7.0	7.0
NL0020103786	II	886.41	False	7.0	7.0
NL0020103875	II	6753.43	False	7.0	7.0
NL0201T00000	II	968.15	False	7.0	7.0
NL0020104670	II	717.26	False	7.0	7.0
NL0020104742	II	225.02	False	7.0	7.0
NL0020104764	II	208.99	False	7.0	7.0
NL0020104785	II	216.57	False	7.0	7.0
NL0020104807	II	254.29	False	7.0	7.0
NL0020104832	II	121.09	False	7.0	7.0
NL0020104845	II	2229.86	False	7.0	7.0
NL0020105068	II	101.05	False	7.0	7.0
NL0020105078	II	978.49	False	7.0	7.0
NL0020105175	II	879.77	False	7.0	7.0

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NL0010201308	VIc	300.91	True	13.0	13.0
NL0010201338	VIc	155.55	True	13.0	13.0
NL0010201354	VIc	243.28	True	13.0	13.0
NL0010201378	VIc	449.92	True	13.0	13.0
NL0010201423	VIc	189.72	True	13.0	13.0
NL0010201442	VIc	37.86	True	17.0	17.0
NL0010201446	VIc	998.33	True	13.0	13.0
NL0010201546	VIc	75.17	True	17.0	17.0
NL0010201553	VIc	381.13	True	13.0	13.0
NL0010201591	VIc	186.39	True	13.0	13.0
NL0010201610	VIc	207.83	True	13.0	13.0
NL0010201631	VIc	538.27	True	13.0	13.0
NL0010201685	VIc	191.65	True	13.0	13.0
NL0010201704	VIc	93.15	True	13.0	13.0
NL0010201713	VIc	533.86	True	13.0	13.0
NL0010201766	VIc	549.08	True	13.0	13.0
NL0010201821	VIc	9.85	True	17.0	17.0
NL0010201822	VIc	764.75	True	13.0	13.0
NL0010201899	VIc	289.31	True	13.0	13.0
NL0010201928	VIc	789.96	True	13.0	13.0
NL0010202007	VIc	306.8	True	13.0	13.0
NL0010202037	VIc	629.72	True	13.0	13.0
NL0010202100	VIc	390.28	True	13.0	13.0
NL0010202139	VIc	890.97	True	13.0	13.0
NL0010202229	VIc	1025.88	True	13.0	13.0
NL0010202331	VIc	233.15	True	13.0	13.0
NL0010202354	VIc	701.0	True	13.0	13.0
NL0010202425	VIc	4970.75	True	12.0	12.0
NL0010202922	VIc	7110.9	True	12.0	12.0
NL0010203633	VIc	3620.19	True	12.0	12.0
NL0102M00000	Va	803.19	True	12.0	12.0
NL0011601268	VIc	2150.87	True	17.0	17.0
NL0116A00000	VIc	345.63	True	17.0	17.0
NL0116A00034	VIc	776.63	True	17.0	17.0
NL0116A00112	VIc	472.48	True	17.0	17.0
NL0115600000	VIc	365.32	True	5.0	5.0
NL0115600036	VIc	1024.12	True	9.0	9.0
NL0126000000	VIc	5234.63	True	9.0	9.0
NL0126500000	VIc	2193.2	True	9.0	9.0
NL0126200000	VIc	1319.55	True	9.0	9.0

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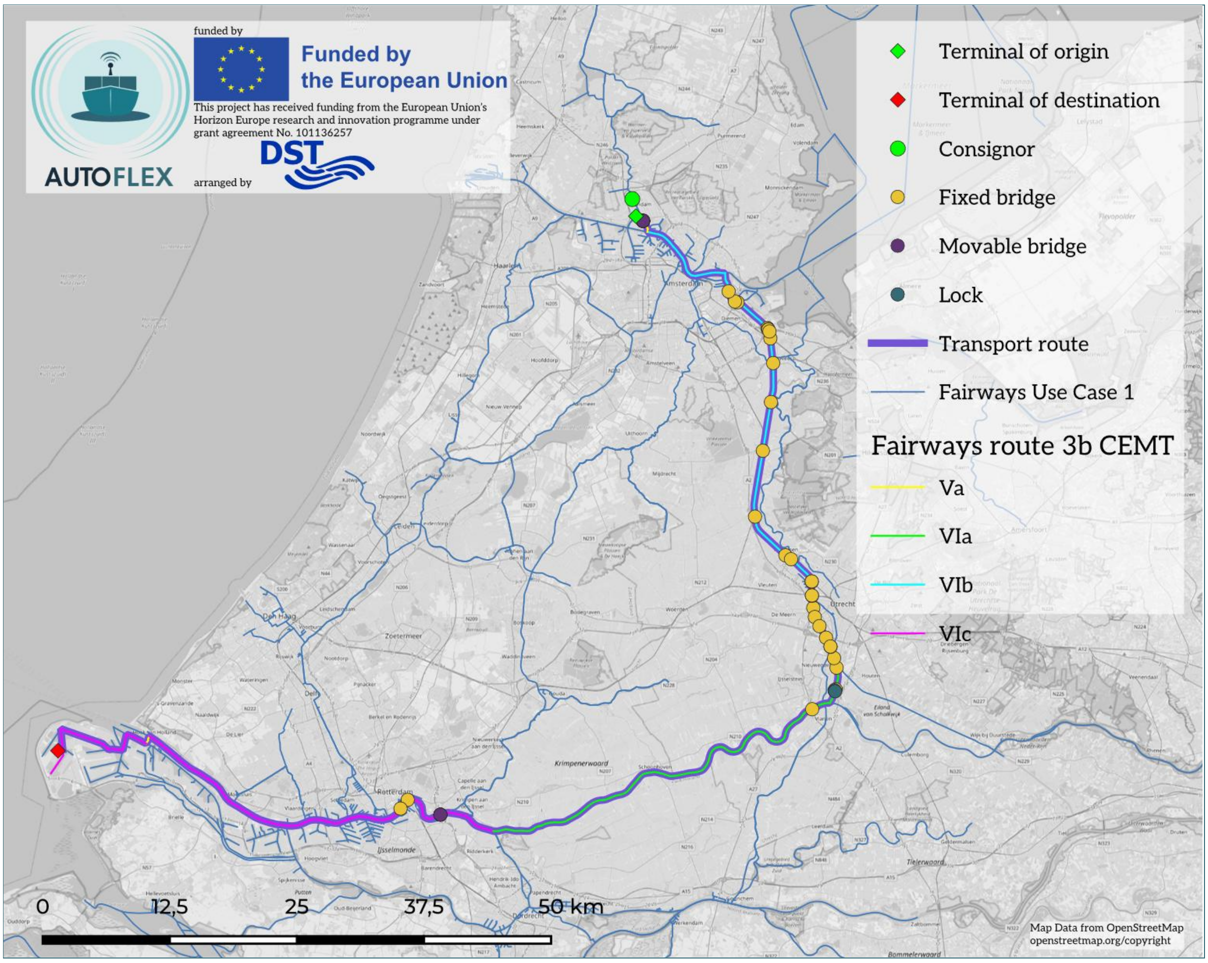

Figure 9-5: Exemplary transport route no. 3b from Zaandam to Rotterdam

Table 9-4: Travel itinerary of transport route no. 3b from Zaandam to Rotterdam

Transport route no. 3b from Zaandam to Rotterdam	
Name of consignor (origin)	Baked goods manufacturer
Pre-haul distance to terminal of origin (road)	2.7 km
Name of seaport (destination)	Port of Rotterdam
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Zaandam, OUDE HAVEN STEIGER 1
ISRS of terminal of origin*	NLZAA01015ZGOH100004
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	RWG – ROTTERDAM WORLD GATEWAY
ISRS of terminal of destination*	NLRTM0126200RWG00014
Type of terminal of destination*	Container terminal

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Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	3
Travelled CEMT classes (inland waterways)*	V a, VI a, VI b, VI c
Number of locks passed*	1
Total distance travelled*	153.18 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0101500000	Va	437.66	False	12.0	12.0
NL0023600108	Va	525.43	False	12.0	12.0
NL0023600042	Va	655.84	False	12.0	12.0
NL0023600029	Va	133.53	False	12.0	12.0
NL0023600000	Va	290.4	False	12.0	12.0
NL0023301615	VIb	1111.79	False	17.0	17.0
NL0023301727	VIb	873.26	False	17.0	17.0
NL0023301814	VIb	133.6	False	17.0	17.0
NL0023301827	VIb	349.25	False	17.0	17.0
NL0023301862	VIb	128.26	False	17.0	17.0
NL0023301875	VIb	440.12	False	17.0	17.0
NL0023301919	VIb	1401.46	False	17.0	17.0
NL0023302059	VIb	1420.28	False	17.0	17.0
NL0023302201	VIb	125.4	False	17.0	17.0
NL0023302214	VIb	70.2	False	17.0	17.0
NL0023302221	VIb	187.34	False	17.0	17.0
NL0023302239	VIb	197.77	False	17.0	17.0
NL0023302259	VIb	415.17	False	17.0	17.0
NL0023302301	VIb	188.71	False	17.0	17.0
NL0023302319	VIb	1322.51	False	17.0	17.0
NL0023302452	VIb	747.72	False	17.0	17.0
NL0023302526	VIb	630.48	False	17.0	17.0
NL0022500000	VIb	601.59	False	17.0	17.0
NL0022500060	VIb	250.27	False	17.0	17.0
NL0022500085	VIb	100.01	False	17.0	17.0
NL0022500095	VIb	635.77	False	17.0	17.0
NL0022500158	VIb	5679.38	False	17.0	17.0
NL0022500726	VIb	3306.22	False	17.0	17.0

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NL0022501057	VIb	2902.27	False	17.0	17.0
NL0022501347	VIb	8807.8	False	17.0	17.0
NL0022502228	VIb	3279.49	False	17.0	17.0
NL0022502556	VIb	6610.72	False	17.0	17.0
NL0022503217	VIb	2896.7	False	17.0	17.0
NL0022503506	VIb	149.98	False	17.0	17.0
NL0022503521	VIb	532.09	False	17.0	17.0
NL0022503574	VIb	465.48	False	17.0	17.0
NL0022503621	VIb	1604.73	False	17.0	17.0
NL0022503781	VIb	4150.54	False	17.0	17.0
NL0022504196	VIb	1139.34	False	17.0	17.0
NL0225E00000	VIa	3092.04	False	12.0	12.0
NL0225E00309	VIa	1086.38	False	12.0	12.0
NL0010308081	VIa	580.54	True	15.0	17.0
NL0010308139	VIa	233.06	True	15.0	17.0
NL0010308162	VIa	11476.19	True	15.0	17.0
NL0010309310	VIa	9052.47	True	15.0	17.0
NL0010310215	VIa	5822.31	True	15.0	17.0
NL0010310797	VIa	7466.84	True	15.0	17.0
NL0010311544	VIa	257.08	True	15.0	17.0
NL0010311569	VIa	4680.91	True	15.0	17.0
NL0010200000	VIc	3085.88	True	17.0	17.0
NL0010200308	VIc	409.1	True	17.0	17.0
NL0010200349	VIc	1349.28	True	17.0	17.0
NL0010200484	VIc	147.95	True	17.0	17.0
NL0010200499	VIc	345.65	True	17.0	17.0
NL0010200533	VIc	97.75	True	17.0	17.0
NL0010200543	VIc	1897.72	True	17.0	17.0
NL0010200733	VIc	603.66	True	17.0	17.0
NL0010200793	VIc	1639.79	True	13.0	13.0
NL0102C00000	VIc	1013.16	True	13.0	13.0
NL0102C00101	VIc	216.5	True	13.0	13.0
NL0102C00122	VIc	640.56	True	13.0	13.0
NL0010201155	VIc	404.37	True	13.0	13.0
NL0010201195	VIc	181.3	True	13.0	13.0
NL0010201213	VIc	854.44	True	13.0	13.0
NL0010201299	VIc	93.95	True	17.0	17.0
NL0010201308	VIc	300.91	True	13.0	13.0
NL0010201338	VIc	155.55	True	13.0	13.0
NL0010201354	VIc	243.28	True	13.0	13.0

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NL0010201378	VIc	449.92	True	13.0	13.0
NL0010201423	VIc	189.72	True	13.0	13.0
NL0010201442	VIc	37.86	True	17.0	17.0
NL0010201446	VIc	998.33	True	13.0	13.0
NL0010201546	VIc	75.17	True	17.0	17.0
NL0010201553	VIc	381.13	True	13.0	13.0
NL0010201591	VIc	186.39	True	13.0	13.0
NL0010201610	VIc	207.83	True	13.0	13.0
NL0010201631	VIc	538.27	True	13.0	13.0
NL0010201685	VIc	191.65	True	13.0	13.0
NL0010201704	VIc	93.15	True	13.0	13.0
NL0010201713	VIc	533.86	True	13.0	13.0
NL0010201766	VIc	549.08	True	13.0	13.0
NL0010201821	VIc	9.85	True	17.0	17.0
NL0010201822	VIc	764.75	True	13.0	13.0
NL0010201899	VIc	289.31	True	13.0	13.0
NL0010201928	VIc	789.96	True	13.0	13.0
NL0010202007	VIc	306.8	True	13.0	13.0
NL0010202037	VIc	629.72	True	13.0	13.0
NL0010202100	VIc	390.28	True	13.0	13.0
NL0010202139	VIc	890.97	True	13.0	13.0
NL0010202229	VIc	1025.88	True	13.0	13.0
NL0010202331	VIc	233.15	True	13.0	13.0
NL0010202354	VIc	701.0	True	13.0	13.0
NL0010202425	VIc	4970.75	True	12.0	12.0
NL0010202922	VIc	7110.9	True	12.0	12.0
NL0010203633	VIc	3620.19	True	12.0	12.0
NL0102M00000	Va	803.19	True	12.0	12.0
NL0011601268	VIc	2150.87	True	17.0	17.0
NL0116A00000	VIc	345.63	True	17.0	17.0
NL0116A00034	VIc	776.63	True	17.0	17.0
NL0116A00112	VIc	472.48	True	17.0	17.0
NL0115600000	VIc	365.32	True	5.0	5.0
NL0115600036	VIc	1024.12	True	9.0	9.0
NL0126000000	VIc	5234.63	True	9.0	9.0
NL0126500000	VIc	2193.2	True	9.0	9.0
NL0126200000	VIc	1319.55	True	9.0	9.0

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9.4 TRANSPORT ROUTE 4: ROTTERDAM – WORMERVEER (ZAANSTAD)

The fourth travel route connects the port of Rotterdam (NL33, Zuid-Holland) to a consignee from Wormerveer (Zaanstad) in the region NL31 (Noord-Holland). An AUTOFLEX CEMT class IV inland vessel is assumed to be used with two container layers on board. Figure 9-6 shows the corresponding route while Table 9-5 presents the travel itinerary. According to the EuRIS travel planner, the reason for having no transport route lies in the dimension of the vessel used, not in a general impassability of the route for inland vessels. Several explanatory approaches may apply here: The bridge opening "Doorvaartopening (vast) Hanenpadsluis"[85], a fixed bridge on the inland waterway "Hanenpadsloot"[86], is erroneously considered to be on the inland waterway "Voorzaan"[87] which is part of the envisioned transport route. The clearance height of this bridge opening is 2.60 metres and its clearance width amounts to 4.75 metres.

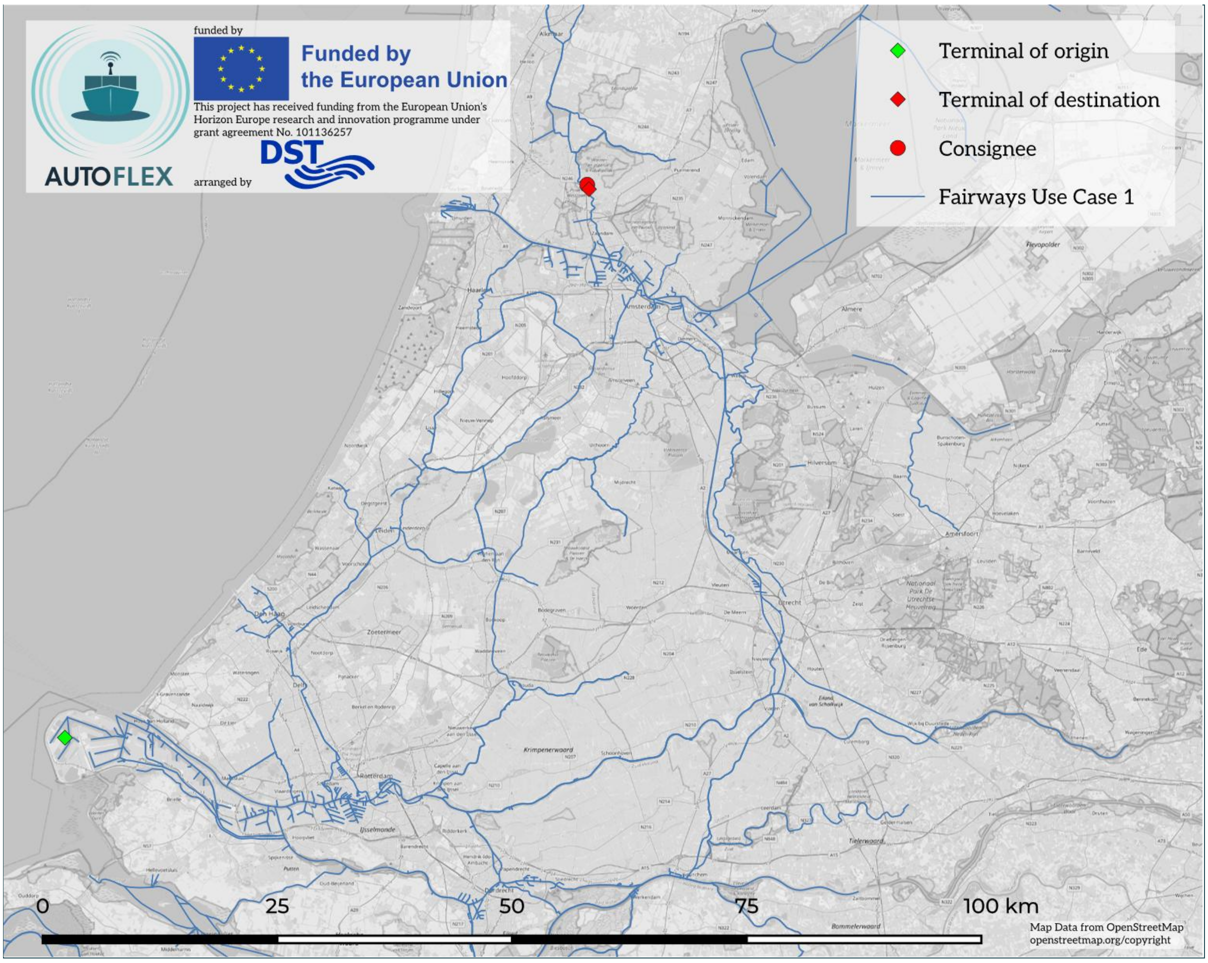

Figure 9-6: Exemplary transport route no. 4 from Rotterdam to Wormerveer (Zaanstad)

85 ISRS code: NLZAA0236H4372400003 (bridge opening)
86 ISRS code: NL0236H00000 (fairway section)
87 ISRS code: NL0023600160 (fairway section)

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Table 9-5: Travel itinerary of transport route no. 4 from Rotterdam to Wormerveer (Zaanstad)

Transport route no. 4 from Rotterdam to Wormerveer (Zaanstad)	
Name of seaport (origin)	Port of Rotterdam
Pre-haul distance to terminal of origin (road)	0 km
Name of consignee (destination)	Food manufacturer
Post-haul distance from terminal of destination (road)	2.6 km
Name of terminal of origin*	RWG - ROTTERDAM WORLD GATEWAY
ISRS of terminal of origin*	NLRTM0126200RWG00014
Type of terminal of origin*	Container terminal
Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: true Reach stacker: true
Name of terminal of destination*	LODERS CROKLAAN
ISRS of terminal of destination*	NLZAD0023600LOD00087
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	n/a
Number of locks passed*	n/a
Total distance travelled*	n/a

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**

Although the official result of the EuRIS travel planner yields no feasible route, a detailed (manual) consideration of the stretches reveals a potentially feasible route, as is presented in Figure A-4 and Table A-6 in the Appendix.

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9.5 TRANSPORT ROUTE 5: BARENDRECHT – WORMERVEER (ZAANSTAD)

The fifth travel route connects a consignor from Barendrecht in the NUTS-2 region NL33 (Zuid-Holland) to a consignee from Wormerveer (Zaanstad) in the region NL31 (Noord-Holland). An AUTOFLEX CEMT class II inland vessel is assumed to be used with one container layer on board. Figure 9-7 shows the corresponding route while Table 9-6 presents the travel itinerary. According to the EuRIS travel planner, the reason for having no transport route lies in the dimension of the vessel used, not in a general impassability of the route for inland vessels. Several explanatory approaches may apply here: The bridge opening “Doorvaartopening (vast) Hanenpadsluis”[88], a fixed bridge on the inland waterway “Hanenpadsloot”[89], is erroneously considered to be on the inland waterway “Voorzaan”[90] which is part of the envisioned transport route. The clearance height of this bridge opening is 2.60 metres and its clearance width amounts to 4.75 metres.

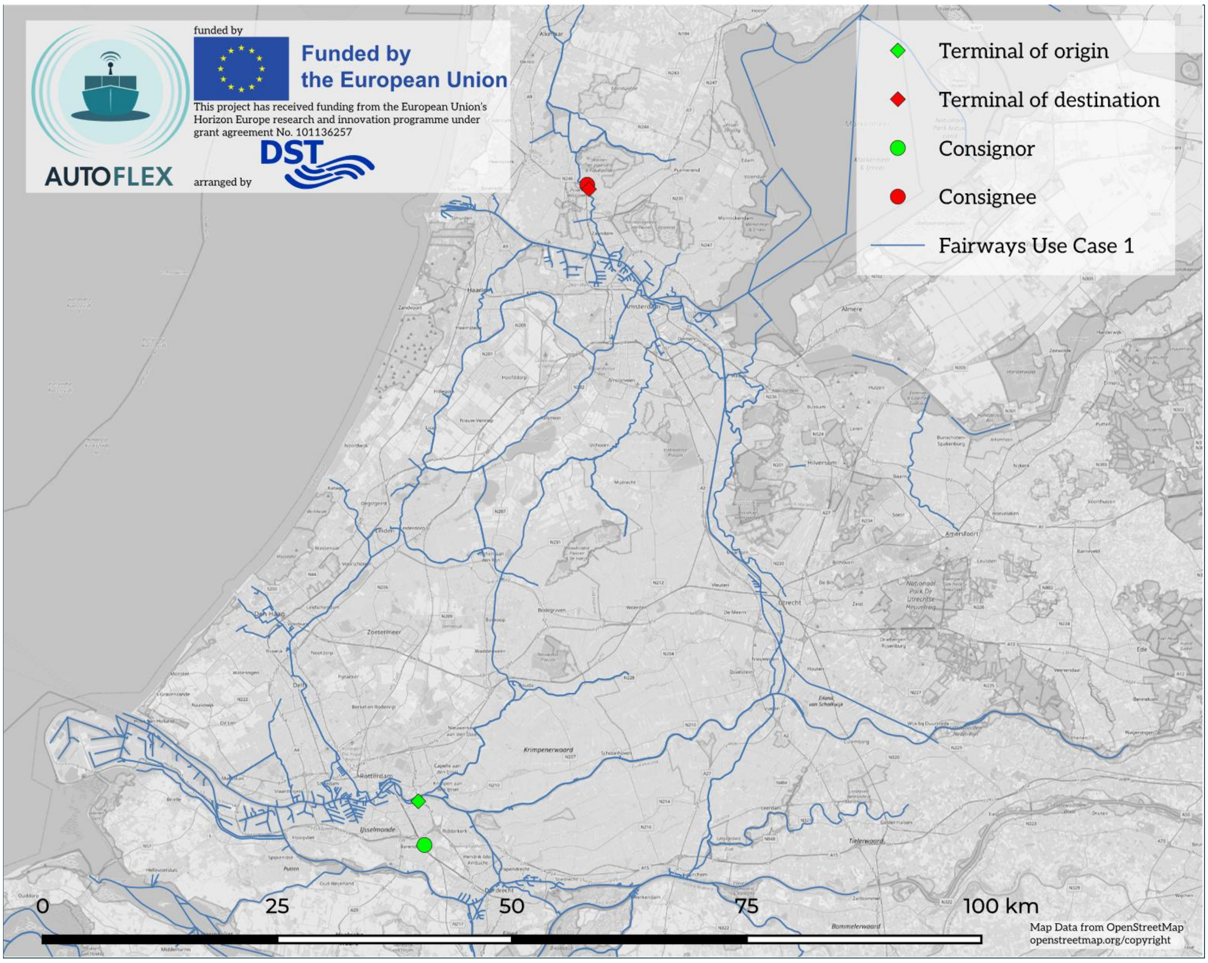

Figure 9-7: Exemplary transport route no. 5 from Barendrecht to Wormerveer (Zaanstad)

88 ISRS code: NLZAA0236H4372400003 (bridge opening)
89 ISRS code: NL0236H00000 (fairway section)
90 ISRS code: NL0023600160 (fairway section)

Table 9-6: Travel itinerary of transport route no. 5 from Barendrecht to Wormerveer (Zaanstad)

Transport route no. 5 from Barendrecht to Wormerveer (Zaanstad)					
Name of consignor (origin)			Food processing company		
Pre-haul distance to terminal of origin (road)			6.5 km		
Name of consignee (destination)			Food manufacturer		
Post-haul distance from terminal of destination (road)			2.6 km		
Name of terminal of origin*			ZUIDDIEPJE PONTMEYER ROTTERDAM		
ISRS of terminal of origin*			NLRTM0102BZDPMR00009		
Type of terminal of origin*			Terminal (not further specified)		
Availability of container transshipment facilities at terminal of origin			Container crane: false Mobile harbour crane: true Reach stacker: false		
Name of terminal of destination*			LODERS CROKLAAN		
ISRS of terminal of destination*			NLZAD0023600LOD00087		
Type of terminal of destination*			Bulk terminal		
Availability of container transshipment facilities at terminal of destination			Container crane: false Mobile harbour crane: false Reach stacker: false		
CEMT class (AUTOFLEX inland vessel)			II		
Container layer(s)			1		
Travelled CEMT classes (inland waterways)*			n/a		
Number of locks passed*			n/a		
Total distance travelled*			n/a		
*acc. to travel planner in EuRIS portal					
Travelled fairway sections					
Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**

Although the official result of the EuRIS travel planner yields no feasible route, a detailed (manual) consideration of the stretches reveals three different potentially feasible routes, as is presented in Figure A-5 and Table A-7, Table A-8, and Table A-9 in the Appendix.

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9.6 TRANSPORT ROUTE 6: GHENT – ANTWERP

The sixth travel route connects a consignor from Ghent in the NUTS-2 region BE23 (Prov. Oost-Vlaanderen) with the seaport of Antwerp (BE21, Prov. Antwerpen). An AUTOFLEX CEMT class IV inland vessel is assumed to be used with two container layers on board. Figure 9-8 shows the corresponding route while Table 9-2 presents the travel itinerary. The same travel plan can be executed via a different route, as can be seen in Figure 9-9 and Table 9-8.

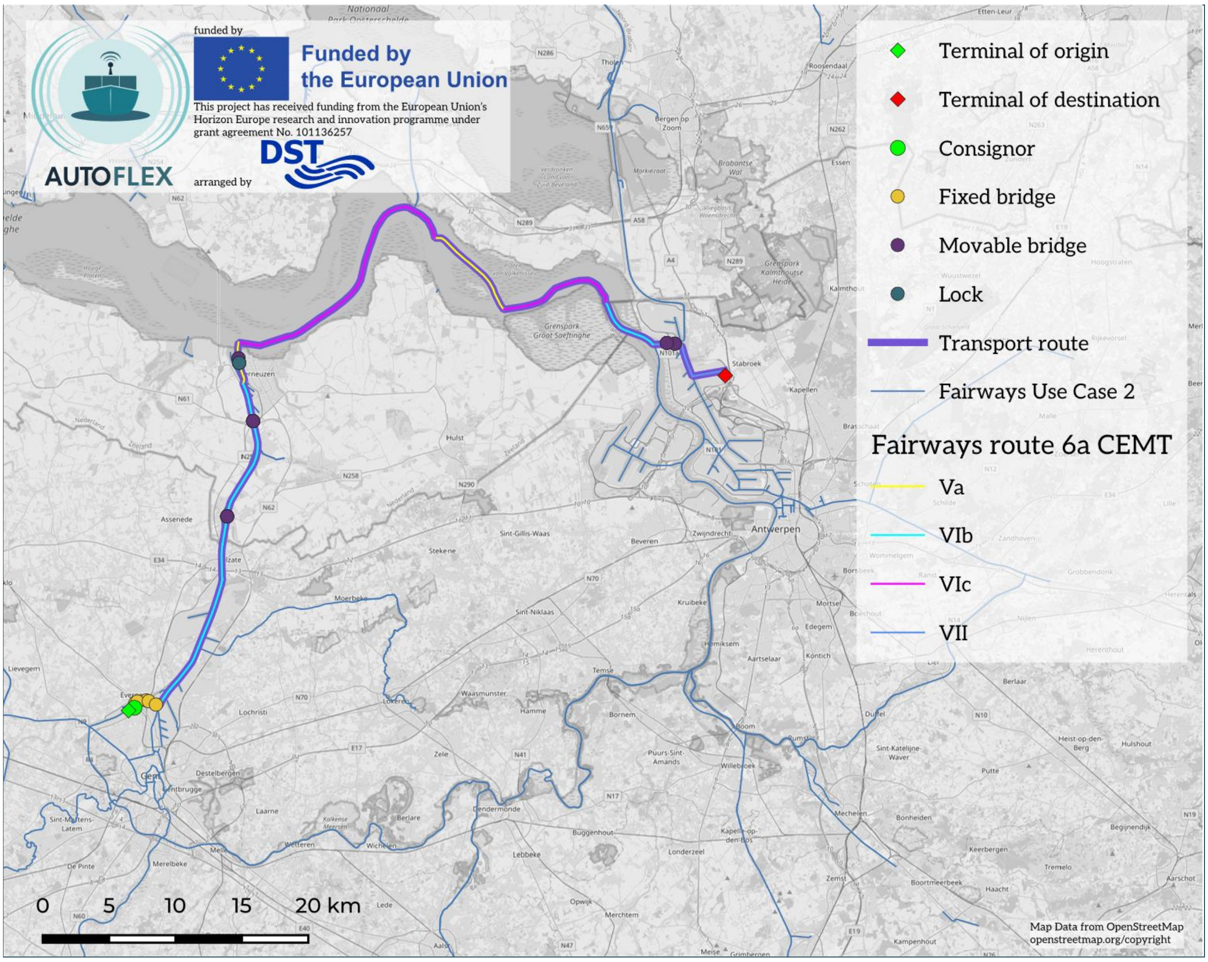

Figure 9-8: Exemplary transport route no. 6a from Ghent to Antwerp

Table 9-7: Travel itinerary of transport route no. 6a from Ghent to Antwerp

Transport route no. 6a from Ghent to Antwerp	
Name of consignor (origin)	Provider of industrial packaging solutions
Pre-haul distance to terminal of origin (road)	0.75 km
Name of seaport (destination)	Port of Antwerp
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Kaai De Pooter Olie
ISRS of terminal of origin*	BEGNE15902T334000022
Type of terminal of origin*	Terminal (not further specified)

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Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Antwerp Container Terminal (K730)
ISRS of terminal of destination*	BEANR017290073000004
Type of terminal of destination*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	V a, VI b, VI c, VII
Number of locks passed*	2
Total distance travelled*	81.3 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
BE1590200000	Va	1098.4	False	12.0	12.0
BE1590100000	Va	1049.31	False	12.0	12.0
BE0531000000	VIb	119.59	False	16.0	16.0
BE0531200000	VIb	725.63	False	16.0	16.0
BE0531400000	VIb	672.58	False	16.0	16.0
BE0531600000	VIb	794.13	False	16.0	16.0
BE0531800000	VIb	3003.42	False	16.0	16.0
BE0532000000	VIb	909.18	False	16.0	16.0
BE0532200000	VIb	1946.08	False	16.0	16.0
BE0532400000	VIb	2553.32	False	16.0	16.0
BE0532500000	VIb	107.76	False	16.0	16.0
BE0532800000	VIb	2584.34	False	16.0	16.0
NL0013001641	VIb	1329.24	False	17.0	17.0
NL0013001774	VIb	215.81	False	17.0	17.0
NL0013001796	VIb	794.05	False	17.0	17.0
NL0013001875	VIb	497.62	False	17.0	17.0
NL0013001925	VIb	3098.05	False	17.0	17.0
NL0013002235	VIb	1903.14	False	17.0	17.0
NL0013002425	VIb	252.62	False	17.0	17.0
NL0013002450	VIb	3199.48	False	17.0	17.0
NL0013002770	VIb	697.31	False	17.0	17.0
NL0013002840	VIb	580.34	False	17.0	17.0
NL0013002898	VIb	244.1	False	17.0	17.0

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NL0130B00000	Va	611.21	False	12.0	12.0
NL0130B00061	Va	927.17	True	12.0	12.0
NL130B200000	Va	320.45	False	17.0	17.0
NL130B200032	Va	365.45	False	12.0	12.0
NL130B200068	Va	972.22	False	12.0	12.0
NL0013106442	VIc	715.32	True	17.0	17.0
NL0013106136	VIc	3052.69	True	17.0	17.0
NL0013105792	VIc	3440.88	True	17.0	17.0
NL0013104741	VIc	10515.16	True	17.0	17.0
NL0013104708	VIc	327.54	True	17.0	17.0
NL0013104669	VIc	390.12	True	17.0	17.0
NL0013104390	VIc	2784.91	True	17.0	17.0
NL0131B00000	Va	7716.7	True	18.0	18.0
NL0013103147	VIc	3539.98	True	17.0	17.0
NL0013103068	VIc	789.23	True	17.0	17.0
NL0131N00000	Vic	4419.72	True	17.0	17.0
NL0013102421	VIc	419.48	True	17.0	17.0
BE1111300000	VIb	4994.56	True	15.0	15.0
BE0174400001	VII	2193.33	False	None	None
BE0173000003	VII	291.43	False	None	None
BE0173000002	VII	1600.1	False	None	None
BE0173000001	VII	534.23	False	None	None
BE0172900001	VII	2000.19	False	None	None

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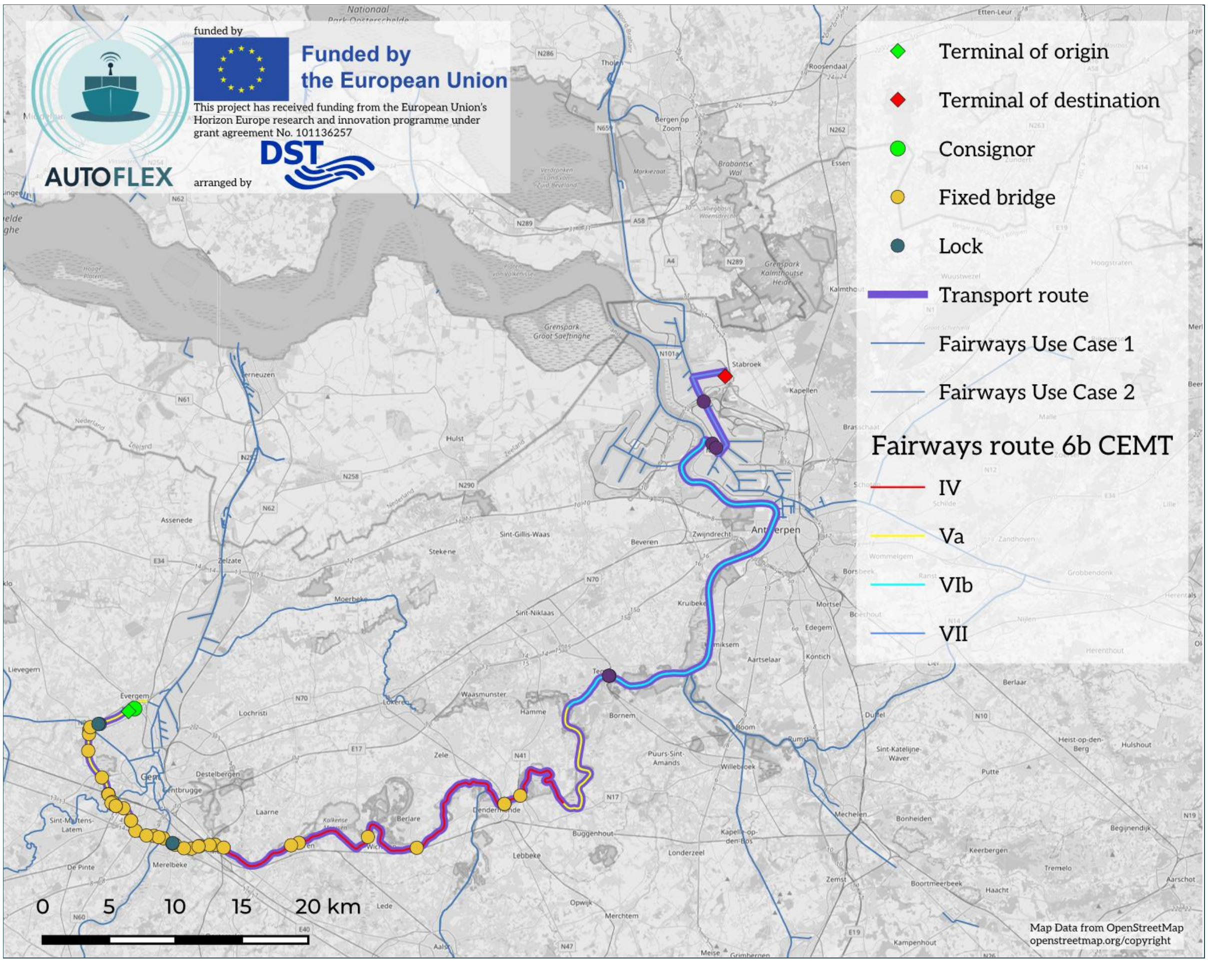

Figure 9-9: Exemplary transport route no. 6b from Ghent to Antwerp

Table 9-8: Travel itinerary of transport route no. 6b from Ghent to Antwerp

Transport route no. 6b from Ghent to Antwerp	
Name of consignor (origin)	Provider of industrial packaging solutions
Pre-haul distance to terminal of origin (road)	0.75 km
Name of consignee (destination)	Port of Antwerp
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Kaai De Pooter Olie
ISRS of terminal of origin*	BEGNE15902T334000022
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Antwerp Container Terminal (K730)
ISRS of terminal of destination*	BEANR017290073000004
Type of terminal of destination*	Terminal (not further specified)

Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	IV, V a, VI b, VII
Number of locks passed*	3
Total distance travelled*	112.25 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
BE1590200000	Va	449.49	False	12.0	12.0
BE1590300000	Va	2642.52	False	12.0	12.0
BE1590400000	Va	658.3	False	12.0	12.0
BE1590500000	Va	6152.79	False	12.0	12.0
BE1590600000	Va	5146.38	False	12.0	12.0
BE1590700000	Va	1020.42	False	12.0	12.0
BE1590800000	IV	2048.76	True	12.0	12.0
BE1590900000	IV	1576.48	True	12.0	12.0
BE1100300000	IV	2585.63	True	14.0	14.0
BE1100400000	IV	7401.49	True	14.0	14.0
BE1100500000	IV	3417.87	True	14.0	14.0
BE1100600000	IV	5810.09	True	14.0	14.0
BE1100700000	IV	4100.23	True	14.0	14.0
BE1100800000	IV	4981.61	True	14.0	14.0
BE1100900000	IV	1905.6	True	14.0	14.0
BE1101000000	IV	1387.49	True	14.0	14.0
BE1101100000	IV	7302.04	True	14.0	14.0
BE1101200000	Va	1570.69	True	14.0	14.0
BE1101300000	Va	507.79	True	14.0	14.0
BE1101400000	Va	3065.3	True	14.0	14.0
BE1101500000	Va	5458.86	True	14.0	14.0
BE1101600000	VIb	4083.0	True	14.0	14.0
BE1101700000	VIb	2250.31	True	14.0	14.0
BE1101800000	VIb	2423.48	True	14.0	14.0
BE1101900000	VIb	1934.4	True	14.0	14.0
BE1102000000	VIb	1155.14	True	15.0	15.0
BE1102100000	VIb	3526.76	True	15.0	15.0
BE1102200000	VIb	1524.44	True	15.0	15.0

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BE1102300000	VIb	839.05	True	15.0	15.0
BE1102400000	VIb	1827.31	True	15.0	15.0
BE1110100000	VIb	1284.17	True	15.0	15.0
BE1110200000	VIb	5195.58	True	15.0	15.0
BE1V901	VIb	310.09	True	9.0	None
BE1V900	VIb	244.36	False	9.0	None
BE1V603	VIb	184.47	False	9.0	None
BE1V604	VIb	559.66	False	9.0	None
BE0175400001	VII	198.42	False	None	None
BE0171200001	VII	1292.86	False	None	None
BE0171200002	VII	491.41	False	None	None
BE0171200003	VII	1247.97	False	None	None
BE0171900001	VII	2091.51	False	None	None
BE0172100001	VII	1714.07	False	None	None
BE0172100002	VII	971.1	False	None	None
BE0172600001	VII	3114.66	False	None	None
BE0172600002	VII	519.12	False	None	None
BE0172800001	VII	1558.46	False	None	None
BE0172800002	VII	519.89	False	None	None
BE0172900001	VII	2000.19	False	None	None

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9.7 TRANSPORT ROUTE 7: ANTWERP – GHENT

The seventh travel route connects the seaport of Antwerp (BE21) with a consignee from Ghent in the region BE23 (Prov. Oost-Vlaanderen). An AUTOFLEX CEMT class IV inland vessel is assumed to be used with one container layer on board. Figure 9-10 shows the corresponding route while Table 9-9 presents the travel itinerary.

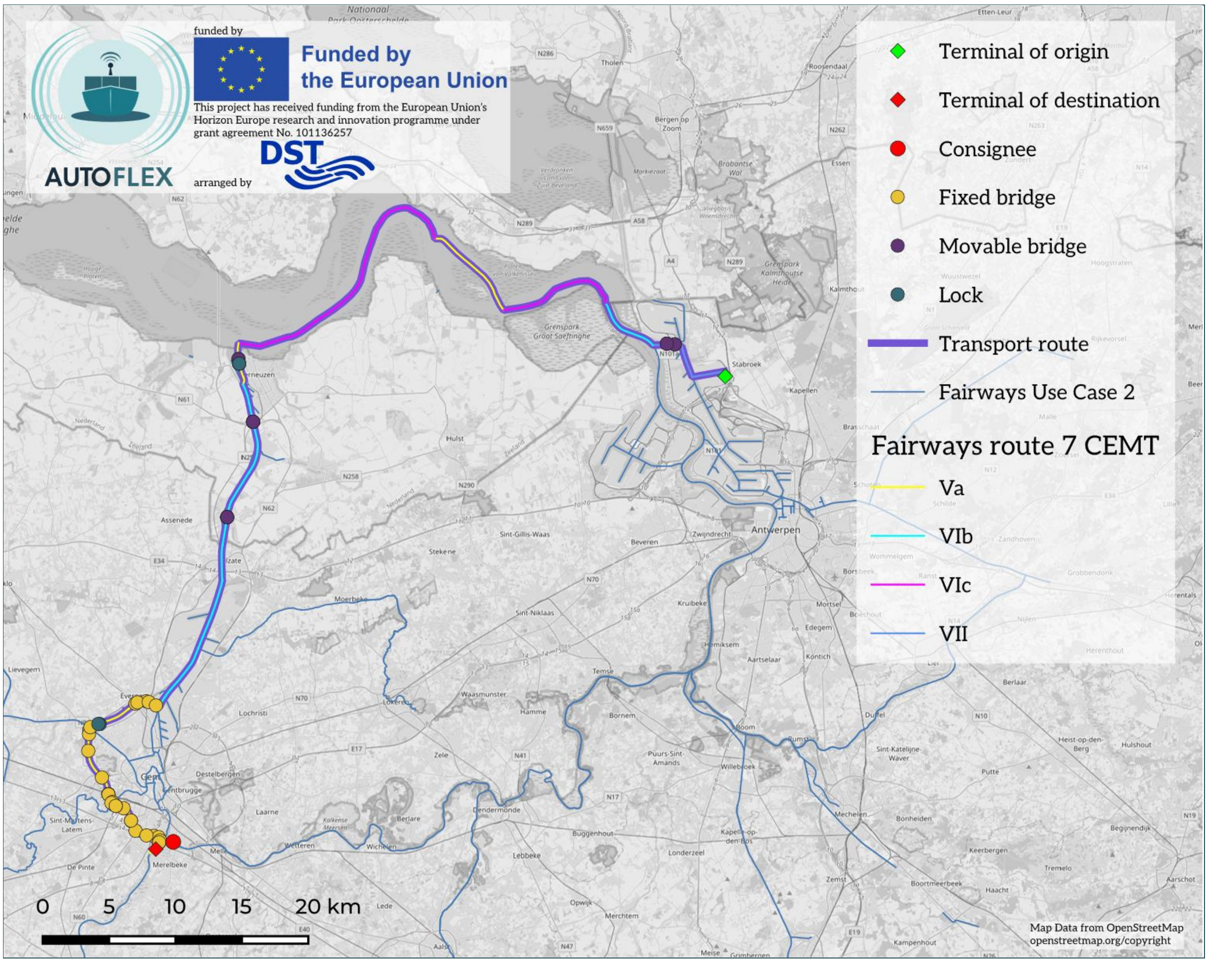

Figure 9-10: Exemplary transport route no. 7 from Antwerp to Ghent

Table 9-9: Travel itinerary of transport route no. 7 from Antwerp to Ghent

Transport route no. 7 from Antwerp to Ghent	
Name of seaport (origin)	Port of Antwerp
Pre-haul distance to terminal of origin (road)	0 km
Name of consignee (destination)	Wholesale chemicals
Post-haul distance from terminal of destination (road)	4.2 km
Name of terminal of origin*	Antwerp Container Terminal (K730)
ISRS of terminal of origin*	BEANR017290073000004
Type of terminal of origin*	Terminal (not further specified)

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Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: true Reach stacker: true
Name of terminal of destination*	KaaiFasiver
ISRS of terminal of destination*	BEGNE15029T029200771
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	V a, VI b, VI c, VII
Number of locks passed*	3
Total distance travelled*	96.97 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
BE0172900001	VII	2000.19	False	None	None
BE0173000001	VII	534.23	False	None	None
BE0173000002	VII	1600.1	False	None	None
BE0173000003	VII	291.43	False	None	None
BE0174400001	VII	2193.33	False	None	None
BE1111300000	VIb	4994.56	True	15.0	15.0
NL0013102421	VIc	419.48	True	17.0	17.0
NL0131N00000	VIc	4419.72	True	17.0	17.0
NL0013103068	VIc	789.23	True	17.0	17.0
NL0013103147	VIc	3539.98	True	17.0	17.0
NL0131B00000	Va	7716.7	True	18.0	18.0
NL0013104390	VIc	2784.91	True	17.0	17.0
NL0013104669	VIc	390.12	True	17.0	17.0
NL0013104708	VIc	327.54	True	17.0	17.0
NL0013104741	VIc	10515.16	True	17.0	17.0
NL0013105792	VIc	3440.88	True	17.0	17.0
NL0013106136	VIc	3052.69	True	17.0	17.0
NL0013106442	VIc	715.32	True	17.0	17.0
NL130B200068	Va	972.22	False	12.0	12.0
NL130B200032	Va	365.45	False	12.0	12.0
NL130B200000	Va	320.45	False	17.0	17.0
NL0130B00061	Va	927.17	True	12.0	12.0
NL0130B00000	Va	611.21	False	12.0	12.0

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NL0013002898	VIb	244.1	False	17.0	17.0
NL0013002840	VIb	580.34	False	17.0	17.0
NL0013002770	VIb	697.31	False	17.0	17.0
NL0013002450	VIb	3199.48	False	17.0	17.0
NL0013002425	VIb	252.62	False	17.0	17.0
NL0013002235	VIb	1903.14	False	17.0	17.0
NL0013001925	VIb	3098.05	False	17.0	17.0
NL0013001875	VIb	497.62	False	17.0	17.0
NL0013001796	VIb	794.05	False	17.0	17.0
NL0013001774	VIb	215.81	False	17.0	17.0
NL0013001641	VIb	1329.24	False	17.0	17.0
BE0532800000	VIb	2584.34	False	16.0	16.0
BE0532500000	VIb	107.76	False	16.0	16.0
BE0532400000	VIb	2553.32	False	16.0	16.0
BE0532200000	VIb	1946.08	False	16.0	16.0
BE0532000000	VIb	909.18	False	16.0	16.0
BE0531800000	VIb	3003.42	False	16.0	16.0
BE0531600000	VIb	794.13	False	16.0	16.0
BE0531400000	VIb	672.58	False	16.0	16.0
BE0531200000	VIb	725.63	False	16.0	16.0
BE0531000000	VIb	119.59	False	16.0	16.0
BE1590100000	Va	1049.31	False	12.0	12.0
BE1590200000	Va	1547.89	False	12.0	12.0
BE1590300000	Va	2642.52	False	12.0	12.0
BE1590400000	Va	658.3	False	12.0	12.0
BE1590500000	Va	6152.79	False	12.0	12.0
BE1590600000	Va	5146.38	False	12.0	12.0
BE1502900000	Va	620.85	False	9.0	9.0

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9.8 TRANSPORT ROUTE 8: MERELBEKE (GHENT) – GHENT

The eighth travel route connects a consignor from Ghent (BE21) with a consignee from the same city. An AUTOFLEX CEMT class II inland vessel is assumed to be used with two container layers on board. Figure 9-11 shows the corresponding route while Table 9-10 presents the travel itinerary.

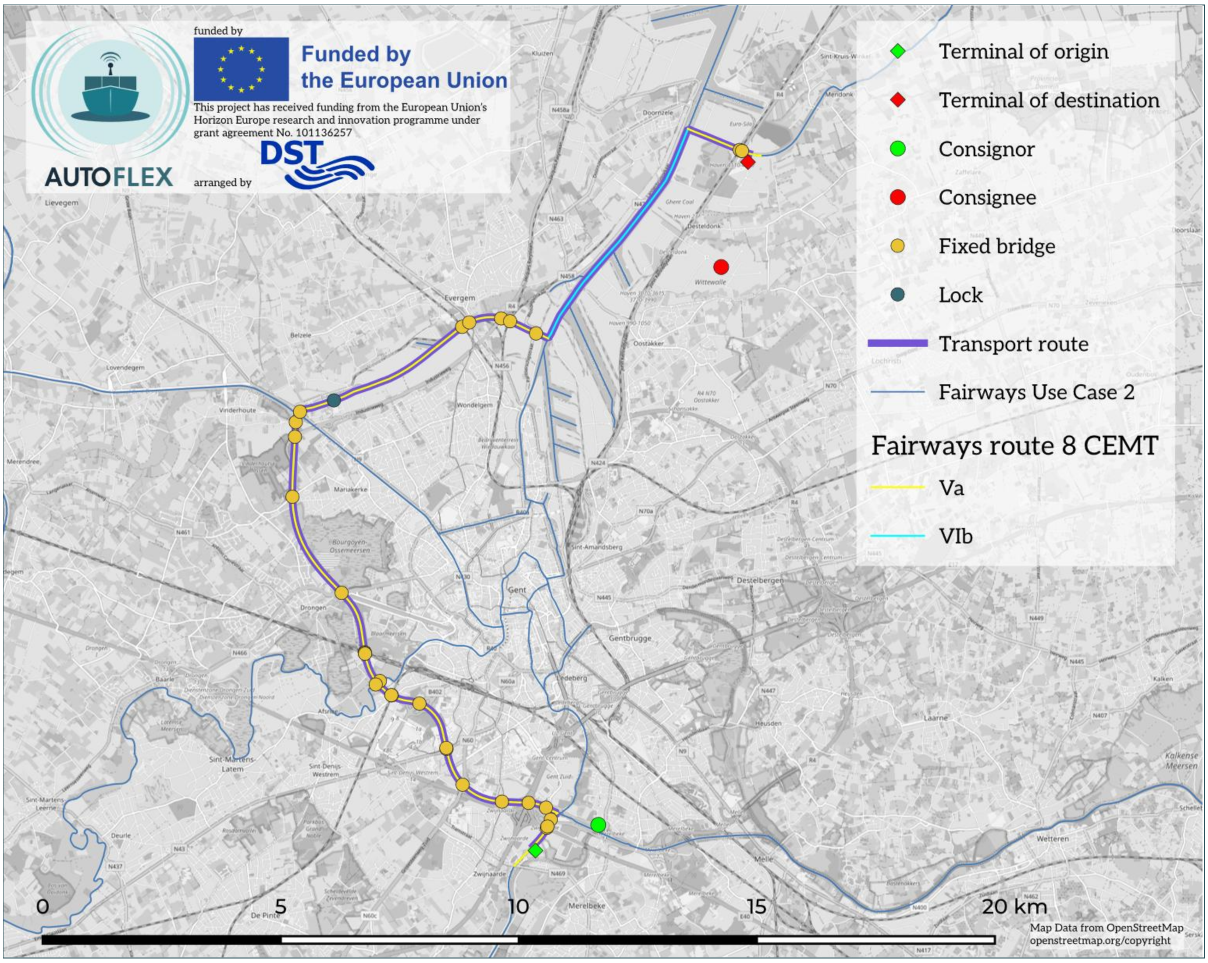

Figure 9-11: Exemplary transport route no. 8 within the city of Ghent

Table 9-10: Travel itinerary of transport route no. 8 within the city of Ghent

Transport route no. 8 within the city of Ghent	
Name of consignor (origin)	Wholesale chemicals
Pre-haul distance to terminal of origin (road)	4.2 km
Name of consignee (destination)	Car paints and car accessories
Post-haul distance from terminal of destination (road)	3.7 km
Name of terminal of origin*	KaaiFasiver
ISRS of terminal of origin*	BEGNE15029T029200771
Type of terminal of origin*	Bulk terminal

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Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Kaai Sita Remediation-Gent (Milieupark)
ISRS of terminal of destination*	BEGNE18103T018600212
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: true Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	V a, VI b
Number of locks passed*	1
Total distance travelled*	24.67 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
BE1502900000	Va	620.85	False	9.0	9.0
BE1590600000	Va	5146.38	False	12.0	12.0
BE1590500000	Va	6152.79	False	12.0	12.0
BE1590400000	Va	658.3	False	12.0	12.0
BE1590300000	Va	2642.52	False	12.0	12.0
BE1590200000	Va	1547.89	False	12.0	12.0
BE1590100000	Va	1049.31	False	12.0	12.0
BE0531000000	VIb	119.59	False	16.0	16.0
BE0531200000	VIb	725.63	False	16.0	16.0
BE0531400000	VIb	672.58	False	16.0	16.0
BE0531600000	VIb	794.13	False	16.0	16.0
BE0531800000	VIb	3003.42	False	16.0	16.0
BE1811200000	Va	1116.53	False	6.0	6.0
BE1810400000	Va	418.96	False	6.0	6.0

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9.9 TRANSPORT ROUTE 9: ANTWERP – GHENT

The ninth travel route connects a consignor from Antwerp in the NUTS-2 region BE21 (Prov. Antwerpen) with a consignee from Ghent in the region BE23 (Prov. Oost-Vlaanderen). An AUTOFLEX CEMT class II inland vessel is assumed to be used with one container layer on board. Figure 9-12: Exemplary transport route no. 9 from Antwerp to Ghent shows the corresponding route while Table 9-11 presents the travel itinerary.

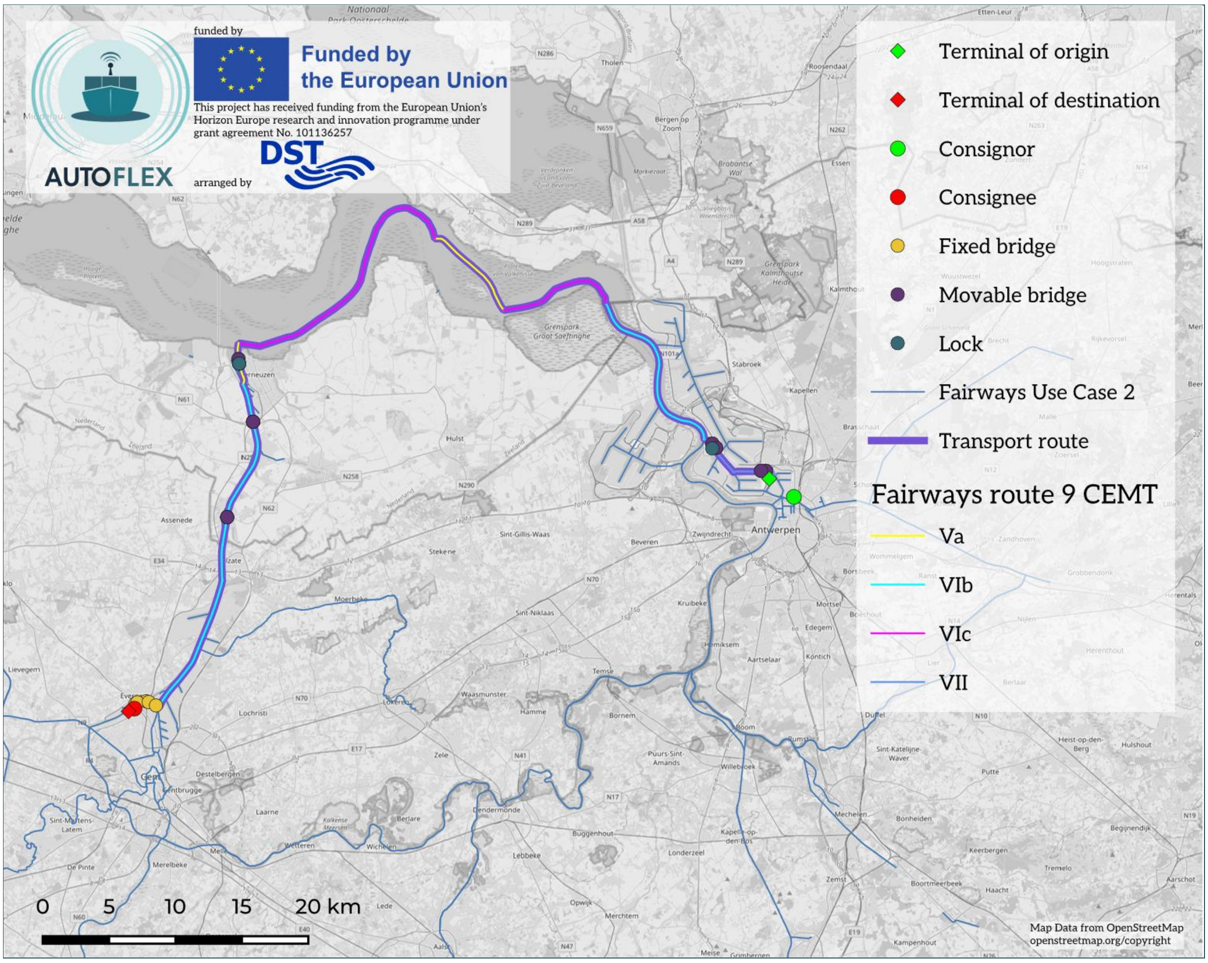

Figure 9-12: Exemplary transport route no. 9 from Antwerp to Ghent

Table 9-11: Travel itinerary of transport route no. 9 from Antwerp to Ghent

Transport route no. 9 from Antwerp to Ghent	
Name of consignor (origin)	Steel trade company
Pre-haul distance to terminal of origin (road)	5.4 km
Name of consignee (destination)	Provider of industrial packaging solutions
Post-haul distance from terminal of destination (road)	0.75 km
Name of terminal of origin*	C. Steinweg Belgium (K125-K133)
ISRS of terminal of origin*	BEANR017120013100024
Type of terminal of origin*	Terminal (not further specified)

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Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker: true
Name of terminal of destination*	Kaai De Pooter Olie
ISRS of terminal of destination*	BEGNE15902T334000022
Type of terminal of destination*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	V a, VI b, VI c, VII
Number of locks passed*	2
Total distance travelled*	89.9 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
BE0171200003	VII	660.2	False	None	None
BE0171900001	VII	2091.51	False	None	None
BE0172100001	VII	1714.07	False	None	None
BE0174200001	VII	1653.89	False	None	None
BE1110900000	VIb	3400.05	True	15.0	15.0
BE1111000000	VIb	1158.34	True	15.0	15.0
BE1111100000	VIb	2914.09	True	15.0	15.0
BE1111200000	VIb	1632.89	True	15.0	15.0
BE1111300000	VIb	4994.56	True	15.0	15.0
NL0013102421	VIc	419.48	True	17.0	17.0
NL0131N00000	VIc	4419.72	True	17.0	17.0
NL0013103068	VIc	789.23	True	17.0	17.0
NL0013103147	VIc	3539.98	True	17.0	17.0
NL0131B00000	Va	7716.7	True	18.0	18.0
NL0013104390	VIc	2784.91	True	17.0	17.0
NL0013104669	VIc	390.12	True	17.0	17.0
NL0013104708	VIc	327.54	True	17.0	17.0
NL0013104741	VIc	10515.16	True	17.0	17.0
NL0013105792	VIc	3440.88	True	17.0	17.0
NL0013106136	VIc	3052.69	True	17.0	17.0
NL0013106442	VIc	715.32	True	17.0	17.0
NL130B200068	Va	972.22	False	12.0	12.0
NL130B200032	Va	365.45	False	12.0	12.0

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NL130B200000	Va	320.45	False	17.0	17.0
NL0130B00061	Va	927.17	True	12.0	12.0
NL0130B00000	Va	611.21	False	12.0	12.0
NL0013002898	VIb	244.1	False	17.0	17.0
NL0013002840	VIb	580.34	False	17.0	17.0
NL0013002770	VIb	697.31	False	17.0	17.0
NL0013002450	VIb	3199.48	False	17.0	17.0
NL0013002425	VIb	252.62	False	17.0	17.0
NL0013002235	VIb	1903.14	False	17.0	17.0
NL0013001925	VIb	3098.05	False	17.0	17.0
NL0013001875	VIb	497.62	False	17.0	17.0
NL0013001796	VIb	794.05	False	17.0	17.0
NL0013001774	VIb	215.81	False	17.0	17.0
NL0013001641	VIb	1329.24	False	17.0	17.0
BE0532800000	VIb	2584.34	False	16.0	16.0
BE0532500000	VIb	107.76	False	16.0	16.0
BE0532400000	VIb	2553.32	False	16.0	16.0
BE0532200000	VIb	1946.08	False	16.0	16.0
BE0532000000	VIb	909.18	False	16.0	16.0
BE0531800000	VIb	3003.42	False	16.0	16.0
BE0531600000	VIb	794.13	False	16.0	16.0
BE0531400000	VIb	672.58	False	16.0	16.0
BE0531200000	VIb	725.63	False	16.0	16.0
BE0531000000	VIb	119.59	False	16.0	16.0
BE1590100000	Va	1049.31	False	12.0	12.0
BE1590200000	Va	1098.4	False	12.0	12.0

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9.10 TRANSPORT ROUTE 10: DEN HAAG – AMSTERDAM

The tenth travel route connects a consignor from Den Haag in the NUTS-2 region NL33 (Zuid-Holland) with the seaport of Amsterdam in the region NL32 (Noord-Holland). An AUTOFLEX CEMT class II inland vessel is assumed to be used with one container layer on board. Figure 9-13 shows the related route while Table 9-12 presents the travel itinerary.

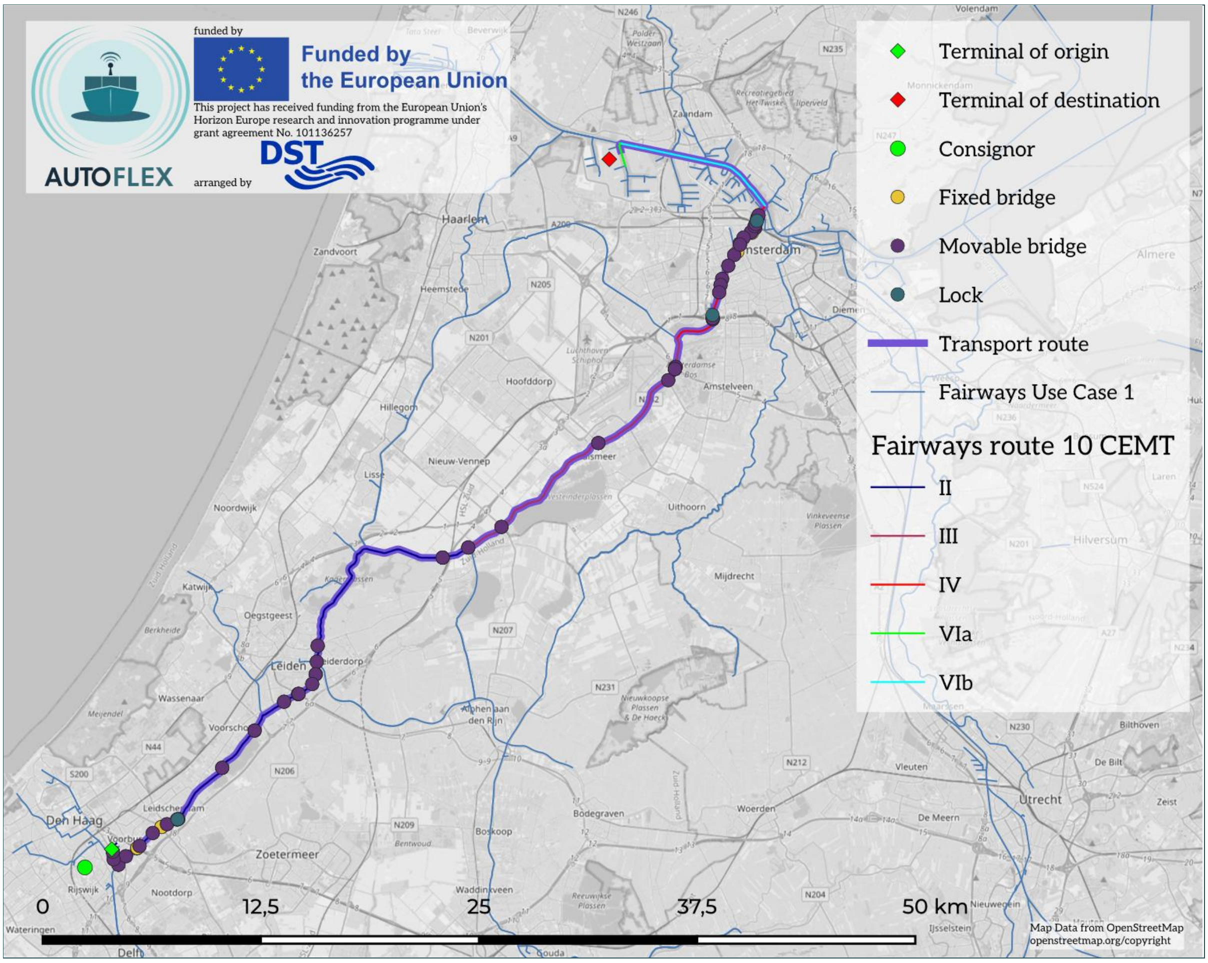

Figure 9-13: Exemplary transport route no. 10 from Den Haag to Amsterdam

Table 9-12: Travel itinerary of transport route no. 10 from Den Haag to Amsterdam

Transport route no. 10 from Den Haag to Amsterdam	
Name of consignor (origin)	Mining equipment provider
Pre-haul distance to terminal of origin (road)	0.9 km
Name of seaport (destination)	Port of Amsterdam
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	's-Gravenhage, Basal
ISRS of terminal of origin*	NLHAG1250A0HAG200005
Type of terminal of origin*	Bulk terminal
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker: false

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Name of terminal of destination*	BUNKERSTEIGER NW ZIJDE CERES
ISRS of terminal of destination*	NLAMS0233MAMBUN00008
Type of terminal of destination*	Container terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	II, III, IV, VI a, VI b
Number of locks passed*	3
Total distance travelled*	69.63 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL1250A00000	II	36.51	False	5.0	5.0
NL0125000036	II	343.58	False	7.0	7.0
NL0201B00000	II	810.74	False	7.0	7.0
NL0020101987	II	11182.04	False	7.0	7.0
NL0020101876	II	1109.94	False	7.0	7.0
NL0020101748	II	1281.0	False	7.0	7.0
NL0020101544	II	2035.4	False	7.0	7.0
NL0020101470	II	736.41	False	7.0	7.0
NL0020101415	II	551.83	False	7.0	7.0
NL0020101064	II	3515.28	False	7.0	7.0
NL0020101016	II	475.14	False	7.0	7.0
NL0020100961	II	548.59	False	7.0	7.0
NL0020100948	II	136.24	False	7.0	7.0
NL0020100896	II	519.08	False	7.0	7.0
NL0020100856	II	402.07	False	7.0	7.0
NL0020100841	II	145.79	False	7.0	7.0
NL0020100826	II	145.81	False	7.0	7.0
NL0020100805	II	218.41	False	7.0	7.0
NL0020100783	II	218.73	False	7.0	7.0
NL0020100717	II	655.09	False	7.0	7.0
NL0020100695	II	218.63	False	7.0	7.0
NL0020100678	II	168.97	False	7.0	7.0
NL0020100628	II	506.68	False	7.0	7.0
NL0020100330	II	2980.69	False	7.0	7.0
NL0020100000	II	3301.11	False	7.0	7.0

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NL0021200998	III	17873.15	False	10.0	10.0
NL0021200748	IV	2492.4	False	10.0	10.0
NL0021200678	IV	703.69	False	10.0	10.0
NL0021200671	IV	72.96	False	10.0	10.0
NL0021200508	IV	1630.36	False	10.0	10.0
NL0021200448	IV	593.52	False	10.0	10.0
NL0021200423	IV	251.38	False	10.0	10.0
NL0021200319	IV	1047.96	False	10.0	10.0
NL0021200311	IV	78.24	False	10.0	10.0
NL0021200270	IV	403.15	False	10.0	10.0
NL0021200211	IV	598.14	False	10.0	10.0
NL0021200171	IV	396.17	False	10.0	10.0
NL0021200156	IV	148.22	False	10.0	10.0
NL0021200141	IV	150.32	False	10.0	10.0
NL0021200125	IV	158.93	False	10.0	10.0
NL0021200090	IV	351.0	False	10.0	10.0
NL0021200080	IV	101.83	False	10.0	10.0
NL0021200063	IV	168.28	False	10.0	10.0
NL0021200028	IV	355.71	False	10.0	10.0
NL0021200000	IV	280.92	False	10.0	10.0
NL0023301919	VIb	1401.46	False	17.0	17.0
NL0023301875	VIb	440.12	False	17.0	17.0
NL0023301862	VIb	128.26	False	17.0	17.0
NL0023301827	VIb	349.25	False	17.0	17.0
NL0023301814	VIb	133.6	False	17.0	17.0
NL0023301727	VIb	873.26	False	17.0	17.0
NL0023301615	VIb	1111.79	False	17.0	17.0
NL0023301419	VIb	1963.47	False	17.0	17.0
NL0023301376	VIb	427.71	False	17.0	17.0
NL0023301217	VIb	1594.14	False	17.0	17.0
NL0023301118	VIb	986.03	False	17.0	17.0
NL0233M00000	VIa	161.02	False	17.0	17.0
NL0233M00016	VIa	0.0	False	9.0	9.0

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9.11 TRANSPORT ROUTE 11: KRIMPEN AAN DEN IJSSEL – ROTTERDAM

The eleventh travel route connects a consignor from Krimpen aan den Ijssel in the NUTS-2 region NL33 (Zuid-Holland) with the seaport of Rotterdam in the same province. One case variant includes an AUTOFLEX CEMT class II inland vessel is assumed to be used with two container layers on board while the other variant foots on an AUTOFLEX CEMT class IV inland vessel with two container layers on board. For the earlier case, Figure 9-14 shows the corresponding route while Table 9-13 presents the travel itinerary. For the latter, the pertaining information can be found in Figure 9-15 and Table 9-14.

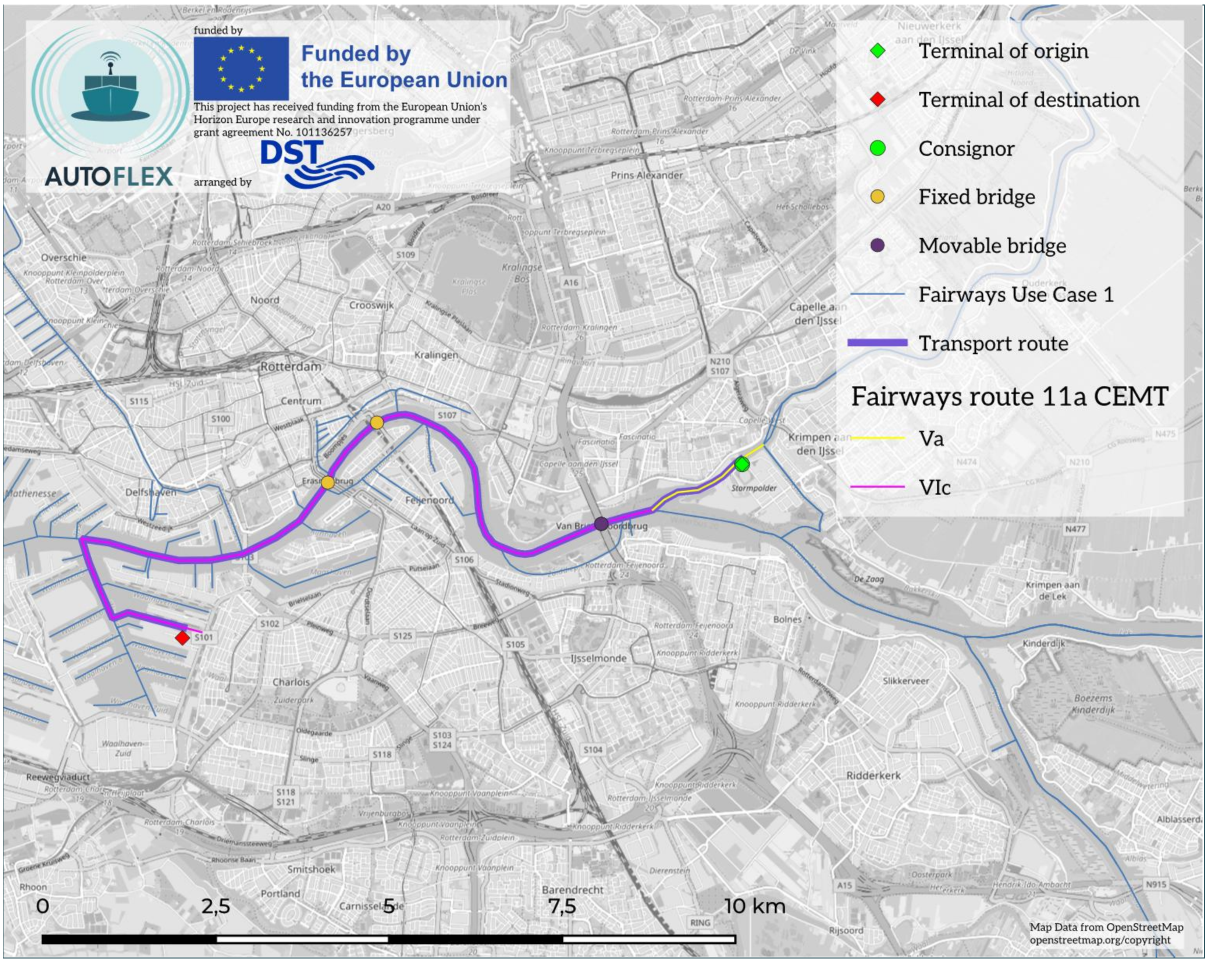

Figure 9-14: Exemplary transport route no. 11 (variant 1) from Krimpen aan den Ijssel to Rotterdam

Table 9-13: Travel itinerary of transport route no. 11 (variant 1) from Krimpen aan den Ijssel to Rotterdam

Transport route no. 11 (variant 1) from Krimpen aan den Ijssel to Rotterdam	
Name of consignor (origin)	Mining equipment provider
Pre-haul distance to terminal of origin (road)	0 km
Name of seaport (destination)	Port of Rotterdam

Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Krimpen aan den IJssel, Hollandia
ISRS of terminal of origin*	NLKAI002110SBGN00193
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Steinweg Pier 2 Waalhaven
ISRS of terminal of destination*	NLRTM01091STEW200013
Type of terminal of destination*	Container terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	V a, VI c
Number of locks passed*	0
Total distance travelled*	13.96 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0021101831	Va	924.03	True	12.0	12.0
NL0010200499	VIc	345.65	True	17.0	17.0
NL0010200533	VIc	97.75	True	17.0	17.0
NL0010200543	VIc	1897.72	True	17.0	17.0
NL0010200733	VIc	603.66	True	17.0	17.0
NL0010200793	VIc	1639.79	True	13.0	13.0
NL0010200957	VIc	416.17	True	13.0	13.0
NL0010200999	VIc	1340.66	True	13.0	13.0
NL0010201133	VIc	217.93	True	13.0	13.0
NL0010201155	VIc	404.37	True	13.0	13.0
NL0010201195	VIc	181.3	True	13.0	13.0
NL0010201213	VIc	854.44	True	13.0	13.0
NL0010201299	VIc	93.95	True	17.0	17.0
NL0010201308	VIc	300.91	True	13.0	13.0
NL0010201338	VIc	155.55	True	13.0	13.0
NL0010201354	VIc	243.28	True	13.0	13.0
NL0010201378	VIc	449.92	True	13.0	13.0
NL0010201423	VIc	189.72	True	13.0	13.0
NL0010201442	VIc	37.86	True	17.0	17.0

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NL0010201446	VIc	998.33	True	13.0	13.0
NL0102F00000	VIc	222.14	True	13.0	13.0
NL0102F00022	VIc	222.76	True	13.0	13.0
NL0102F00044	VIc	280.82	True	13.0	13.0
NL0102F00072	VIc	324.88	True	13.0	13.0
NL0102F00105	VIc	182.79	True	13.0	13.0
NL0109100000	VIc	1333.53	True	13.0	13.0

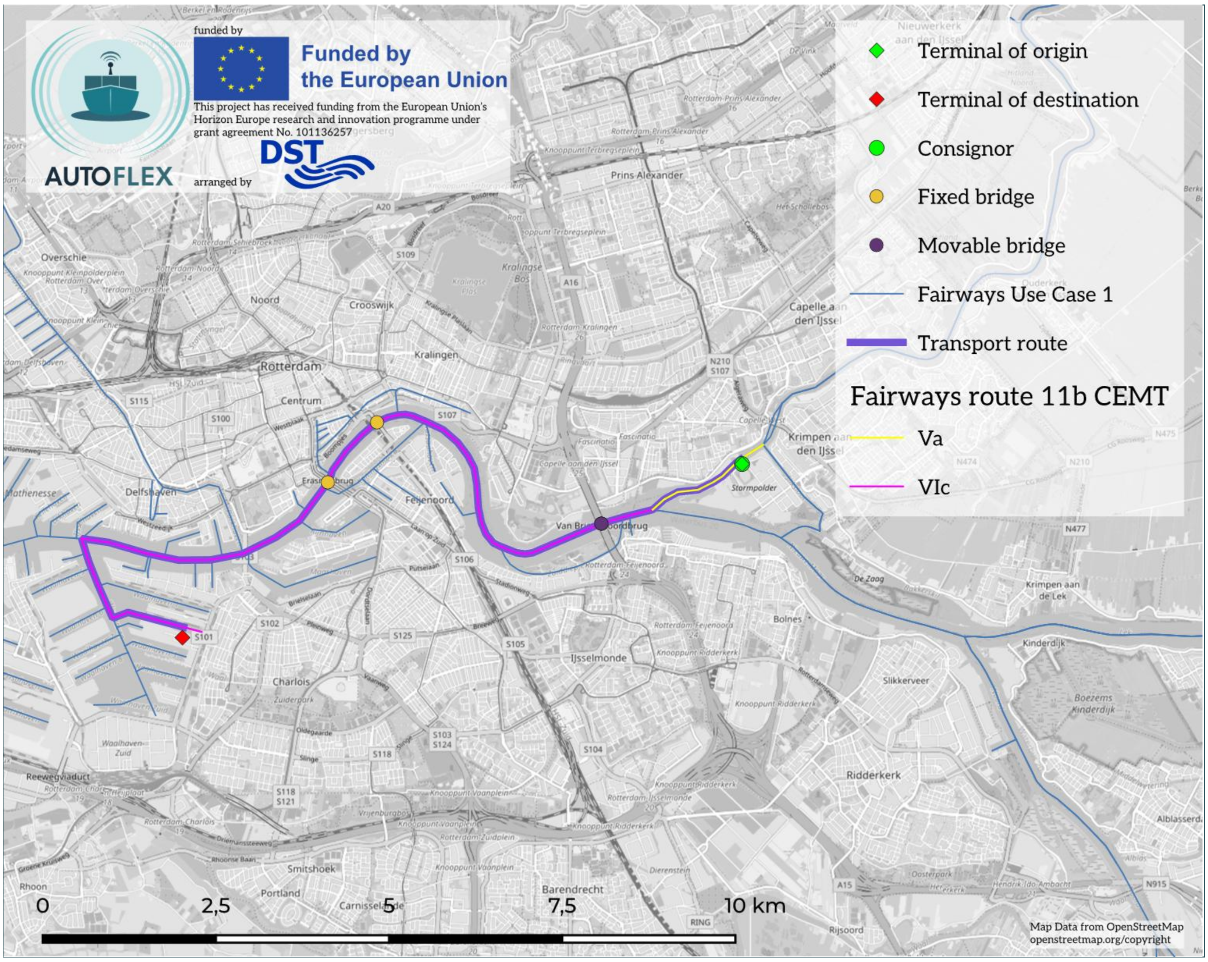

Figure 9-15: Exemplary transport route no. 11 (variant 2) from Krimpen aan den Ijssel to Rotterdam

Table 9-14: Travel itinerary of transport route no. 11 (variant 2) from Krimpen aan den Ijssel to Rotterdam

Transport route no. 11 (variant 2) from Krimpen aan den Ijssel to Rotterdam	
Name of consignor (origin)	Mining equipment provider
Pre-haul distance to terminal of origin (road)	0 km
Name of seaport (destination)	Port of Rotterdam
Post-haul distance from terminal of destination (road)	0 km

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Name of terminal of origin*	Krimpen aan den IJssel, Hollandia
ISRS of terminal of origin*	NLKAI002110SBGN00193
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Steinweg Pier 2 Waalhaven
ISRS of terminal of destination*	NLRTM01091STEW200013
Type of terminal of destination*	Container terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	V a, VI c
Number of locks passed*	0
Total distance travelled*	13.96 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL0021101831	Va	924.03	True	12.0	12.0
NL0010200499	VIc	345.65	True	17.0	17.0
NL0010200533	VIc	97.75	True	17.0	17.0
NL0010200543	VIc	1897.72	True	17.0	17.0
NL0010200733	VIc	603.66	True	17.0	17.0
NL0010200793	VIc	1639.79	True	13.0	13.0
NL0010200957	VIc	416.17	True	13.0	13.0
NL0010200999	VIc	1340.66	True	13.0	13.0
NL0010201133	VIc	217.93	True	13.0	13.0
NL0010201155	VIc	404.37	True	13.0	13.0
NL0010201195	VIc	181.3	True	13.0	13.0
NL0010201213	VIc	854.44	True	13.0	13.0
NL0010201299	VIc	93.95	True	17.0	17.0
NL0010201308	VIc	300.91	True	13.0	13.0
NL0010201338	VIc	155.55	True	13.0	13.0
NL0010201354	VIc	243.28	True	13.0	13.0
NL0010201378	VIc	449.92	True	13.0	13.0
NL0010201423	VIc	189.72	True	13.0	13.0
NL0010201442	VIc	37.86	True	17.0	17.0
NL0010201446	VIc	998.33	True	13.0	13.0

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NL0102F00000	VIc	222.14	True	13.0	13.0
NL0102F00022	VIc	222.76	True	13.0	13.0
NL0102F00044	VIc	280.82	True	13.0	13.0
NL0102F00072	VIc	324.88	True	13.0	13.0
NL0102F00105	VIc	182.79	True	13.0	13.0
NL0109100000	VIc	1333.53	True	13.0	13.0

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9.12 TRANSPORT ROUTE 12: ROTTERDAM – SPIJKENISSE

The twelfth travel route connects the seaport of Rotterdam with a consignee from Spijkenisse in the same NUTS-2 region NL33 (Zuid-Holland). An AUTOFLEX CEMT class II inland vessel is assumed to be used with two container layers on board. Figure 9-16 shows the corresponding route while Table 9-15 presents the travel itinerary.

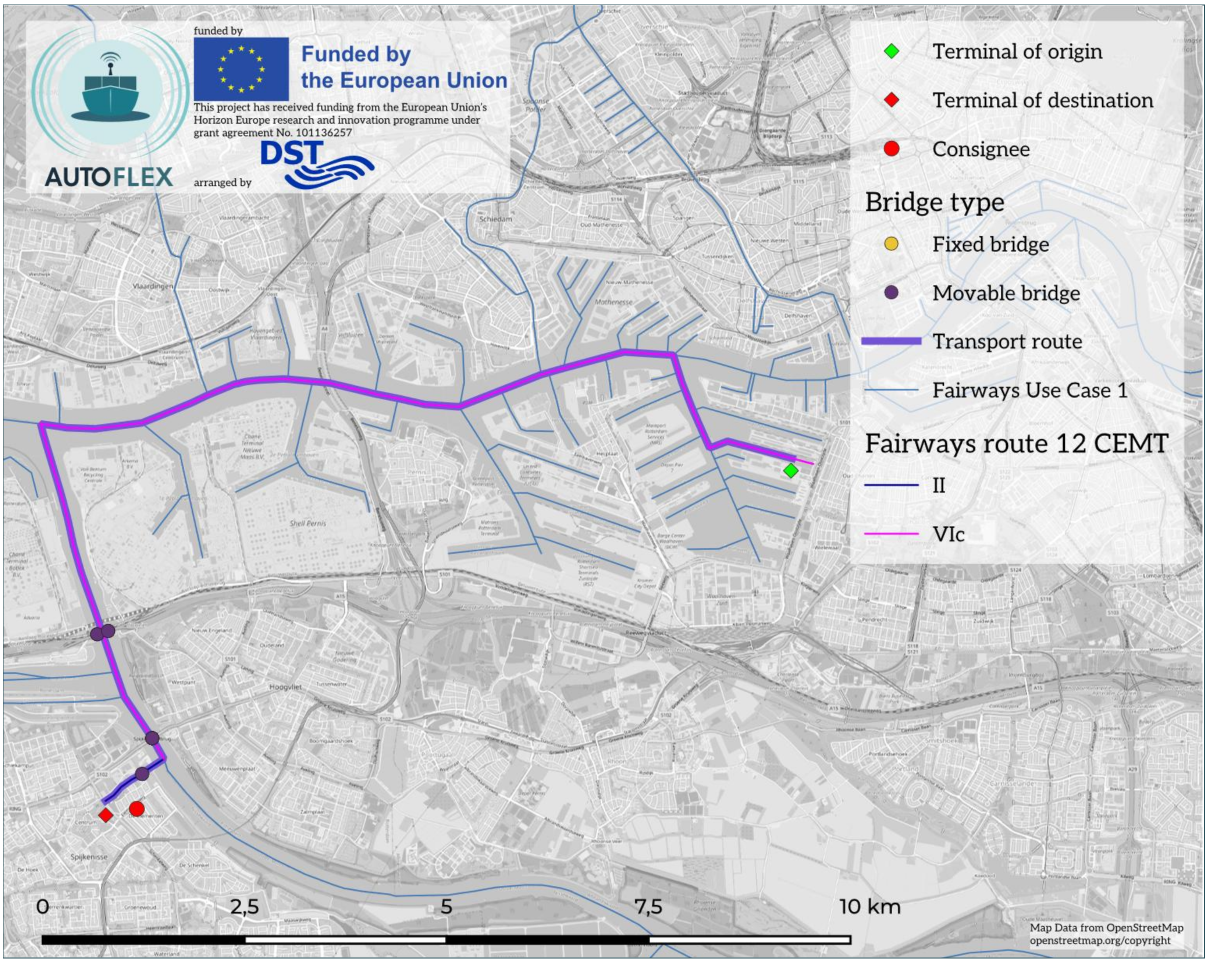

Figure 9-16: Exemplary transport route no. 12 from Rotterdam to Spijkenisse

Table 9-15: Travel itinerary of transport route no. 12 from Rotterdam to Spijkenisse

Transport route no.12 from Rotterdam to Spijkenisse	
Name of consignor (origin)	Port of Rotterdam
Pre-haul distance to terminal of origin (road)	0 km
Name of consignee (destination)	Industrial plant construction company
Post-haul distance from terminal of destination (road)	16.6 km
Name of terminal of origin*	Steinweg Pier 2 Waalhaven
ISRS of terminal of origin*	NLRTM01091STEW200013
Type of terminal of origin*	Container terminal

Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: true Reach stacker: true
Name of terminal of destination*	Wachtgebied ViN(61099)
ISRS of terminal of destination*	NLSPI006862047000009
Type of terminal of destination*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	2
Travelled CEMT classes (inland waterways)*	II, VI c
Number of locks passed*	0
Total distance travelled*	15.99 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0109100000	VIc	842.27	True	13.0	13.0
NL0102F00105	VIc	182.79	True	13.0	13.0
NL0102F00072	VIc	324.88	True	13.0	13.0
NL0102F00044	VIc	280.82	True	13.0	13.0
NL0102F00022	VIc	222.76	True	13.0	13.0
NL0102F00000	VIc	222.14	True	13.0	13.0
NL0010201546	VIc	75.17	True	17.0	17.0
NL0010201553	VIc	381.13	True	13.0	13.0
NL0010201591	VIc	186.39	True	13.0	13.0
NL0010201610	VIc	207.83	True	13.0	13.0
NL0010201631	VIc	538.27	True	13.0	13.0
NL0010201685	VIc	191.65	True	13.0	13.0
NL0010201704	VIc	93.15	True	13.0	13.0
NL0010201713	VIc	533.86	True	13.0	13.0
NL0010201766	VIc	549.08	True	13.0	13.0
NL0010201821	VIc	9.85	True	17.0	17.0
NL0010201822	VIc	764.75	True	13.0	13.0
NL0010201899	VIc	289.31	True	13.0	13.0
NL0010201928	VIc	789.96	True	13.0	13.0
NL0010202007	VIc	306.8	True	13.0	13.0
NL0010202037	VIc	629.72	True	13.0	13.0
NL0010202100	VIc	390.28	True	13.0	13.0
NL0010202139	VIc	890.97	True	13.0	13.0

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NL0010202229	VIc	1025.88	True	13.0	13.0
NL0010202331	VIc	233.15	True	13.0	13.0
NL0011102758	VIc	3202.88	True	13.0	13.0
NL0011102726	VIc	323.84	True	13.0	13.0
NL0011102634	VIc	912.77	True	13.0	13.0
NL0068600000	II	875.63	True	7.0	7.0

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9.13 TRANSPORT ROUTE 13: GHENT – GHENT

The travel route no. 13 connects a consignor from Ghent in the NUTS-2 region BE23 (Prov. Oost-Vlaanderen) with the seaport of the same city. An AUTOFLEX CEMT class IV inland vessel is assumed to be used with one container layer on board. Figure 9-17 shows the corresponding route while Table 9-16 presents the travel itinerary.

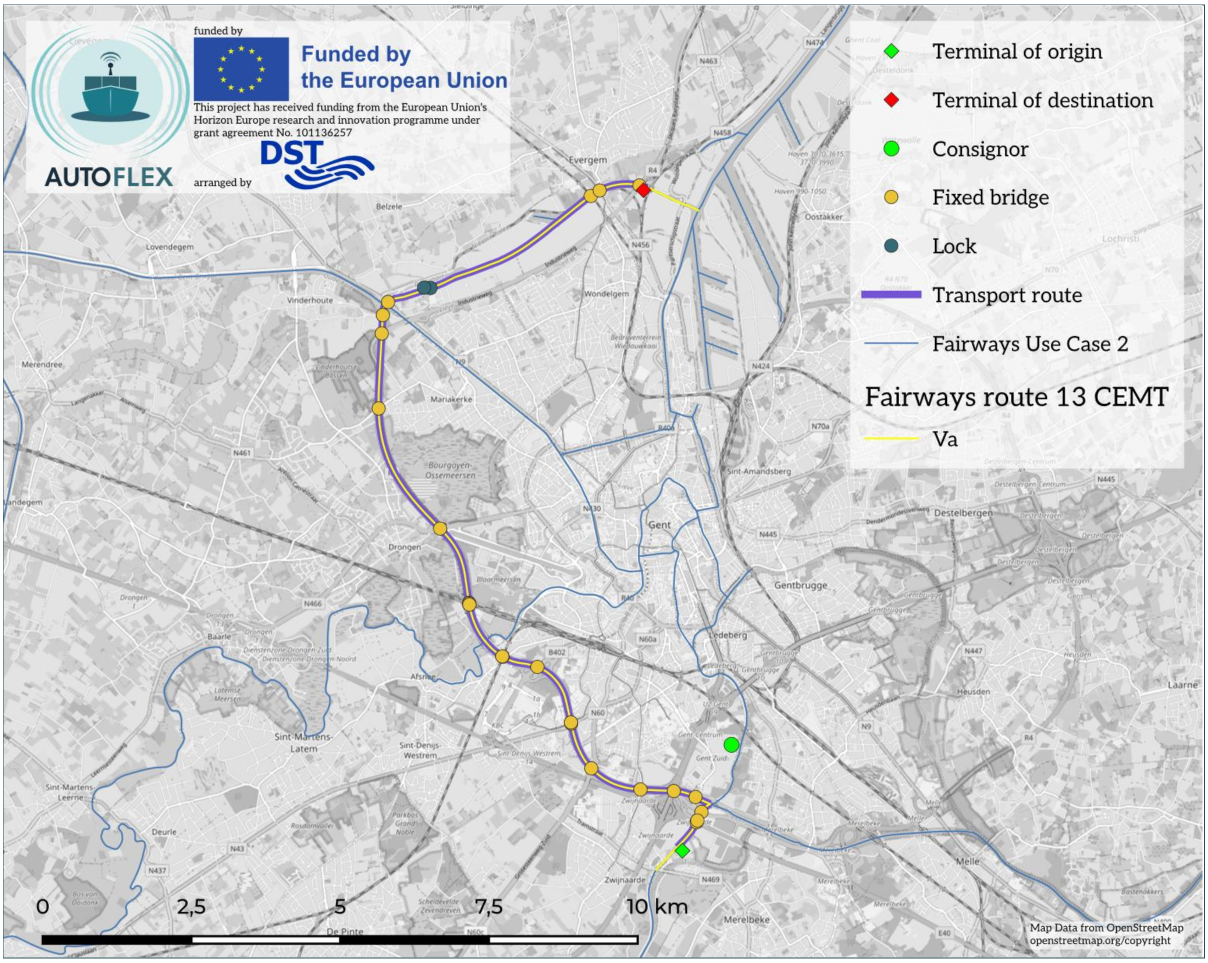

Figure 9-17: Exemplary transport route no. 13 within the city of Ghent

Table 9-16: Travel itinerary of transport route no. 13 within the city of Ghent

Transport route no. 13 within the city of Ghent	
Name of consignor (origin)	Recycling centre
Pre-haul distance to terminal of origin (road)	6.7 km
Name of seaport (destination)	Port of Ghent
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	KaaiFasiver
ISRS of terminal of origin*	BEGNE15029T029200771
Type of terminal of origin*	Bulk terminal

Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Kaai AC Materials
ISRS of terminal of destination*	BEGNE15901T334100010
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	V a
Number of locks passed*	1
Total distance travelled*	16.77 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
BE1502900000	Va	620.85	False	9.0	9.0
BE1590600000	Va	5146.38	False	12.0	12.0
BE1590500000	Va	6152.79	False	12.0	12.0
BE1590400000	Va	658.3	False	12.0	12.0
BE1590300000	Va	2642.52	False	12.0	12.0
BE1590200000	Va	1547.89	False	12.0	12.0
BE1590100000	Va	51.29	False	12.0	12.0

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9.14 TRANSPORT ROUTE 14: WIJNEGEM – ANTWERP

The travel route no. 14 connects a consignor from Wijnegem in the NUTS-2 region BE21 (Prov. Antwerpen) with the Port of Antwerp. An AUTOFLEX CEMT class IV inland vessel is assumed to be used with three container layers on board. Figure 9-18 shows the corresponding route while Table 9-17 presents the travel itinerary.

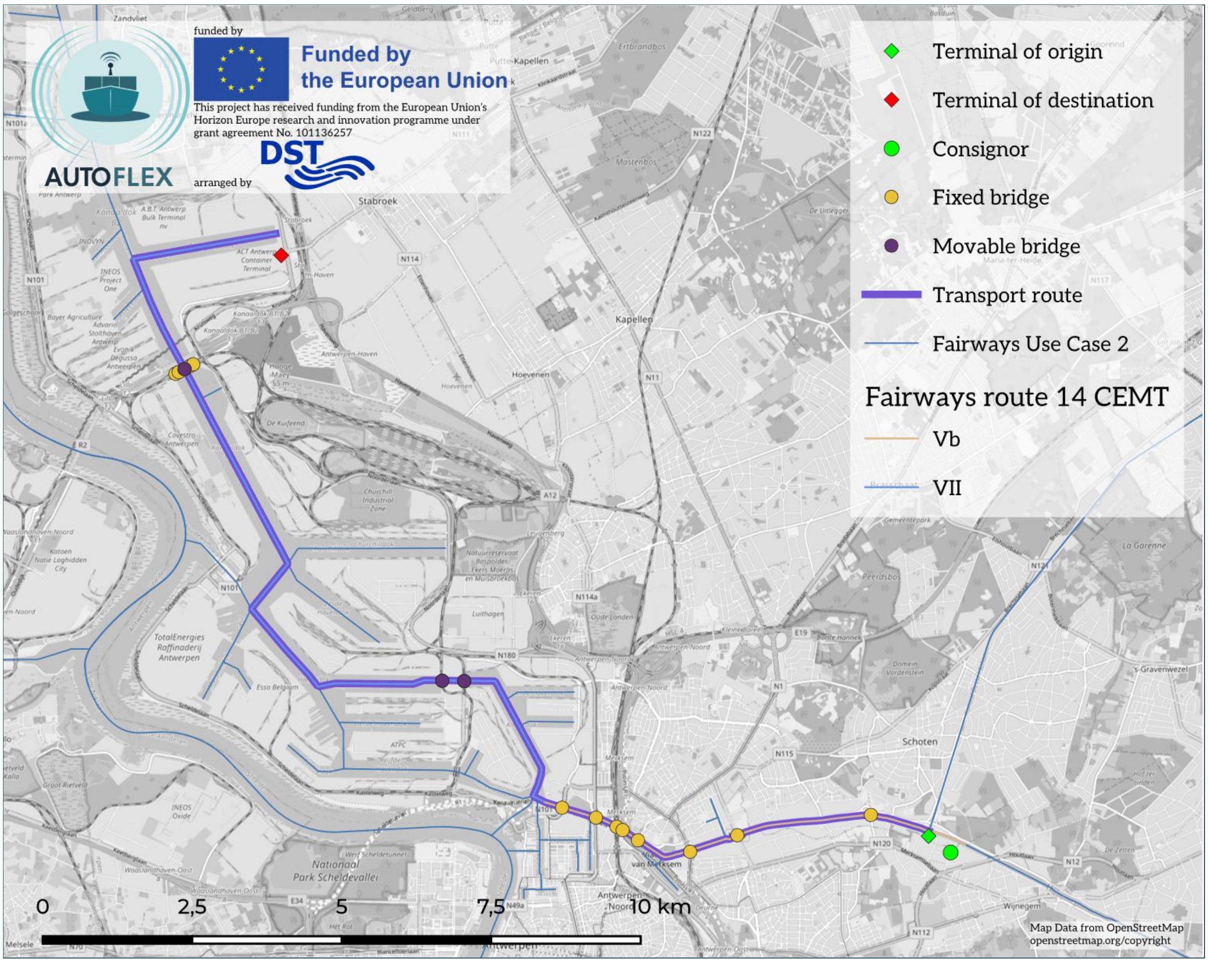

Figure 9-18: Exemplary transport route no. 14 from Wijnegem to Antwerp

Table 9-17: Travel itinerary of transport route no. 14 from Wijnegem to Antwerp

Travel itinerary of transport route no. 14 from Wijnegem to Antwerp	
Name of consignor (origin)	Industrial equipment supplier
Pre-haul distance to terminal of origin (road)	2.9 km
Name of seaport (destination)	Port of Antwerp
Post-haul distance from terminal of destination (road)	0 km
Name of terminal of origin*	Transportbetond De Beuckelaer
ISRS of terminal of origin*	BESCT02049T311101227
Type of terminal of origin*	Bulk terminal

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Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: false Reach stacker: false
Name of terminal of destination*	Bonapartesluis tot Kattendijksluis
ISRS of terminal of destination*	BEANR11102T028400061
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: true Mobile harbour crane: true Reach stacker: true
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	3
Travelled CEMT classes (inland waterways)*	V b, VII
Number of locks passed*	0
Total distance travelled*	22.54 km

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
BE0204900000	Vb	0.0	False	12.0	12.0
BE0205000000	Vb	3035.75	False	11.0	11.0
BE0205100000	Vb	452.26	False	11.0	11.0
BE0205300000	Vb	1082.0	False	11.0	11.0
BE0205400000	Vb	832.14	False	11.0	11.0
BE0205500000	Vb	591.84	False	11.0	11.0
BE0205600000	Vb	791.53	False	11.0	11.0
BE0175300001	VII	228.79	False	None	None
BE0171200001	VII	1292.86	False	None	None
BE0171200002	VII	491.41	False	None	None
BE0171200003	VII	1247.97	False	None	None
BE0171900001	VII	2091.51	False	None	None
BE0172100001	VII	1714.07	False	None	None
BE0172100002	VII	971.1	False	None	None
BE0172600001	VII	3114.66	False	None	None
BE0172600002	VII	519.12	False	None	None
BE0172800001	VII	1558.46	False	None	None
BE0172800002	VII	519.89	False	None	None
BE0172900001	VII	2000.19	False	None	None
BE0204900000	Vb	0.0	False	12.0	12.0
BE0205000000	Vb	3035.75	False	11.0	11.0

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10 CONCLUSION AND OUTLOOK

As for every (transport) service, both the supply and the demand side need to be taken into consideration in the design phase of that service. Referring to the analysis of the supply side – equalling the task T2.1 of the AUTOFLEX project, this report presents the results of a collection of geographic, nautical, technical, and economic information about the use case areas of the envisioned AUTOFLEX transport service. Eventually, the relevant points of interest with respect to inland waterway transport in the considered geographic areas were to compile for a consolidation of requirements and framework conditions which need to be considered in the further process of designing both a novel intermodal waterborne transport system and small, flexible, automated, zero-emission inland vessels.

The following types of geographic and nautical PoIs in the two use case areas in Belgium and the Netherlands have been scrutinised and collected for a use in the further course of the research project:

- the inland waterways themselves with detailed information about the fairway parameters to enable efficient sailing,
- the berths and transshipment points for vessel and cargo handling, and
- the locks and weirs as well as bridges and overhead structures, which may cause mandatory technical and operational requirements to be taken into account and delays in transport lead time due to the respective operation times.

Both Belgium and the Netherlands feature a number of favourable factors for the deployment of the envisioned AUTOFLEX transport service using SFAZ inland vessels:

- Both countries are endowed with a dense inland waterway network, featuring a considerable share of small inland waterways (of the CEMT classes I to IV).
- The two considered geographic areas of Use Case 1 and Use Case 2 comprise a total of more than 2,250 terminals of different types, offering plenty of potential for the deployment of the AUTOFLEX transport system components, such as S&C hubs, TPT, and MDC.
- Numerous larger seaports are situated in both countries.
- Both the Dutch and the Flemish inland waterway network are well-connected – with each other as well as with neighbouring networks, such as the Wallonian waterways, the French waterways, the West German Canal network and – last but not least – the Rhine and the Rhine-Alpine Corridor as Europe's busiest inland waterway corridor.
- Both countries feature sufficient economic activity and, thereby, potential for domestic and regional waterborne transports – either as part of seaport hinterland traffic or of continental transports.
- Both Belgium and the Netherlands exhibit a large number of operators (and other members of the respective IWT ecosystems) which already operate on the larger waterways of both countries, and which could easily expand their operation to the smaller waterways with SFAZ inland vessels once proven technically feasible and economically viable.

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The work on task T2.1, which is documented in this report, also relates to other work streams of the AUTOFLEX project:

While task T2.1 has focused on the supply side and examined the infrastructural possibilities of deploying the new AUTOFLEX transport system, task T2.2 took the complementary role of analysing the demand side and determining the market potential (including a potential modal shift effect from road to inland waterways). Mutual work streams have fertilised one another as promising geographic and nautical corridors have been scrutinised from an economic perspective while economic hotspots have been examined with respect to existing and potential waterborne transport services.

The work documented in this report includes the work on T2.3 which includes a mapping of the existing transport solutions available and a gap analysis on potentially missing logistical offerings in the Use Case 1 and Use Case 2 areas. The synopsis of the existing waterborne transport services with the sites of potential consignors, such as production units and distribution centres, and the inland waterway infrastructure clearly provides a good understanding of the potential of the new AUTOFLEX transport system.

Moreover, the findings documented in this work are directly used for the modelling of components of the discrete-event simulation model (as part of task T2.4). The missing components and their respective properties are to be built in for the subsequent simulation-based performance validation of the new AUTOFLEX transport system.

Next, the results of the geographic and nautical analysis have yielded candidate locations for the different AUTOFLEX transport system components. These locations and pertaining conditions and requirements are to be taken into consideration in the respective work streams of the tasks T3.1 (Stow & Charge hubs), T3.2 (temporary port terminals), and T3.3 (mobile distribution centres) when designing technical and organisational aspects of the envisioned solutions tailored to the needs of one or several of those candidate locations.

Concerning the vessel development in WP 4, the vast majority of information requirements of task T4.2 have been addressed by this report so that the concept development of an uncrewed SFAZ inland vessel can be pursued. The iterative development process will make use of the findings at different points in the process.

Furthermore, the investigation and outline of potential business models of the new AUTOFLEX transport system, which is concentrated in task T5.1, will make use of the geographic, nautical, technical, and economic information about the use case areas and the potential operation of a waterborne transport service which is compiled and provided in this report.

Eventually, the work documented in this report forms the base of a transferability analysis of both the new AUTOFLEX transport system, the individual AUTOFLEX system components, and the SFAZ inland vessels. The conditions and requirements from the two considered geographic areas of Use Case 1 and Use Case 2 are consolidated in the form of a criteria catalogue which again will be matched against the properties of potential service areas, such as Wallonia, northern France, and western Germany.

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A APPENDIX

Table A-1: Navigational zones of inland waterways in the Use Case 1 and Use Case 2 areas

Waterway name	Country	Navigational zone
Maritime Scheldt (downstream of Antwerp open anchorage).	Belgium	3
Rhine.	Netherlands	3
Eemmeer.	Netherlands	3
Alkmaardermeer.	Netherlands	3
Gouwzee.	Netherlands	3
Buiten IJ.	Netherlands	3
Afgesloten IJ.	Netherlands	3
Noordzeekanaal.	Netherlands	3
Port of IJmuiden.	Netherlands	3
Rotterdam port area.	Netherlands	3
Nieuwe Maas.	Netherlands	3
Noord.	Netherlands	3
Oude Maas.	Netherlands	3
Beneden Merwede.	Netherlands	3
Nieuwe Merwede.	Netherlands	3
Dordtsche Kil.	Netherlands	3
Boven Merwede.	Netherlands	3
Waal.	Netherlands	3
Neder Rijn.	Netherlands	3
Lek.	Netherlands	3
Amsterdam-Rhine Canal.	Netherlands	3
Veerse Meer.	Netherlands	3
Scheldt-Rhine Canal as far as the mouth in the Volkerak.	Netherlands	3
Amer.	Netherlands	3
Bergsche Maas.	Netherlands	3
Gooimeer.	Netherlands	3
Europoort.	Netherlands	3
Caland Canal, east of Benelux Port.	Netherlands	3
Hartel Canal.	Netherlands	3
IJsselmeer, including the Markermeer and the IJmeer but excluding the Gouwzee.	Netherlands	2

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Rotterdam Waterweg and the Scheur.	Netherlands	2
Hollands Diep.	Netherlands	2
Haringvliet and Vuile Gat, including the waterways between Goeree-Overflakkee on the one hand and Voorne-Putten and Hoekse Waard on the other.	Netherlands	2
Hellegat.	Netherlands	2
Volkerak.	Netherlands	2
Krammer.	Netherlands	2
Grevelingenmeer and Brouwershavense Gat, including all the waterways between Schouwen-Duiveland and Goeree-Overflakkee.	Netherlands	2
Keten, Mastgat, Zijpe Eastern Scheldt and Roompot, including the waterways between Walcheren, Noord-Beveland and Zuid-Beveland on the one hand and Schouwen-Duiveland and Tholen on the other hand, excluding the Scheldt-Rhine Canal.	Netherlands	2
Scheldt and Western Scheldt and its mouth on the sea, including the waterways between Zeeland Flanders on the one hand and Walcheren and Zuid-Beveland on the other, excluding the Scheldt-Rhine Canal.	Netherlands	2
Breeddiep.	Netherlands	2
Beer Canal and adjacent ports.	Netherlands	2
Caland Canal, west of Benelux Port.	Netherlands	2
Krabbenkreek.	Netherlands	2

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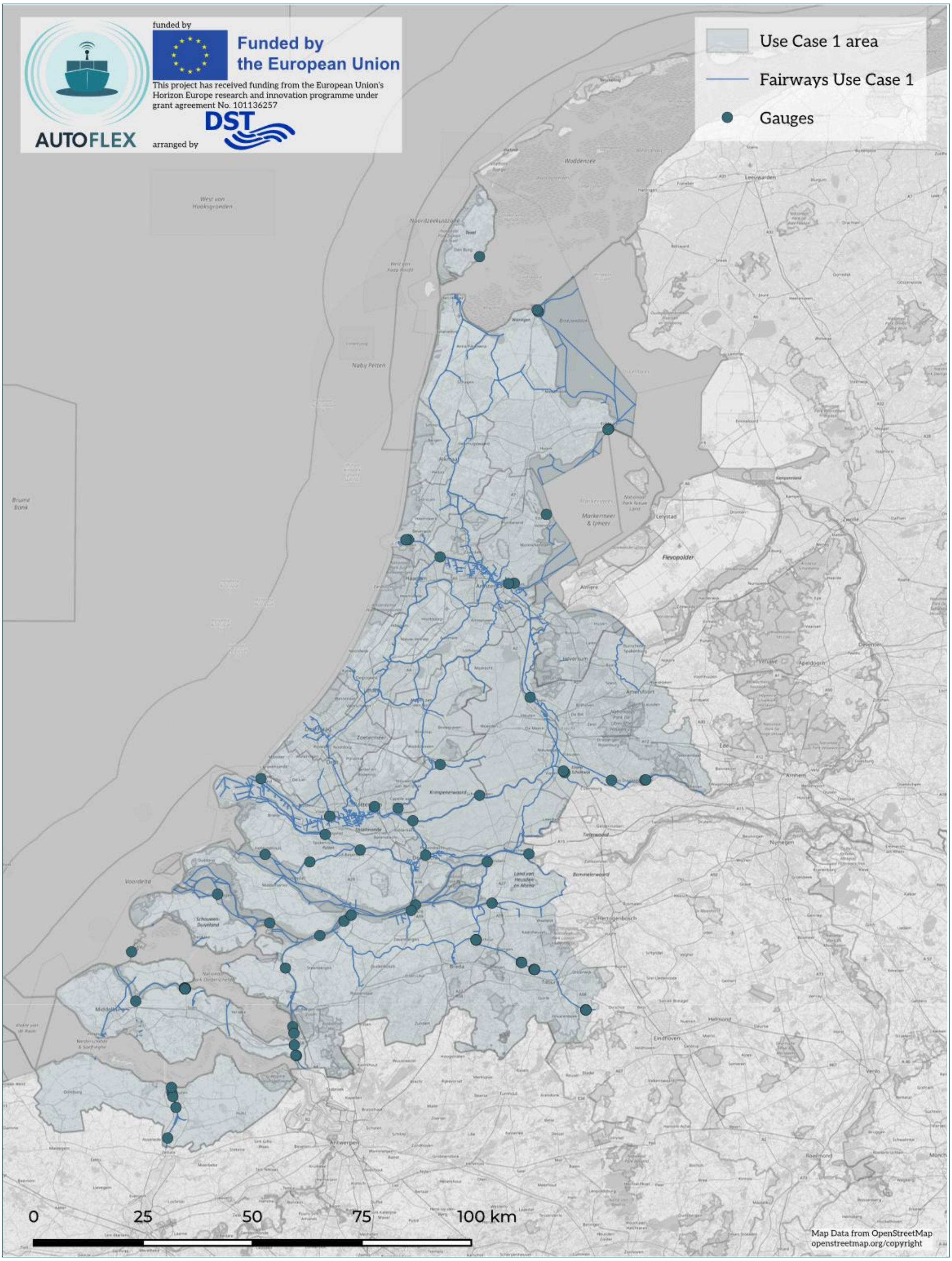

Figure A-1: Gauges in the Use Case 1 area

Table A-2: Port cities (including number of assigned terminals and berths) in the Use Case 1 area

Name	Number of terminals	Number of berths	Number of transshipment berths	UN/ LOCODE	Geo-coordinates
Aalsmeer	2	3	1	AAM	POINT (4.79373 52.295395)
Alblasserdam	11	0	0	ABL	POINT (4.66 51.86)
Akersloot	3	0	0	AKL	POINT (4.746803 52.570729)
Alkmaar	2	12	0	ALK	POINT (4.756197 52.629516)
Amsterdam	211	469	46	AMS	POINT (4.819215 52.400227)
Alphen aan den Rijn	2	28	0	APN	POINT (4.672102 52.112371)
Arnemuiden	1	0	0	ARM	POINT (3.660192 51.497492)
Assendelft	3	0	0	ASD	POINT (4.724524 52.431432)
Beusichem	1	0	0	BEC	POINT (5.281119 51.963882)
Beverwijk	10	7	0	BEV	POINT (4.665949 52.472125)
Bergambacht	3	8	0	BGB	POINT (4.78689 51.920769)
Bovenkarspel	2	0	0	BOV	POINT (5.25 52.68)
Breda	1	0	0	BRD	POINT (4.759617 51.608478)
Brielle	2	0	0	BRI	POINT (4.175371 51.909503)
Brouwershaven	3	0	0	BRO	POINT (3.834445 51.751197)
Breezand	2	3	0	BRZ	POINT (4.774013 52.882991)
Bergen op Zoom	6	21	1	BZM	POINT (4.27 51.5)
Capelle aan den IJssel	4	1	0	CPI	POINT (4.590912 51.922764)
Cruquius	1	6	1	CRU	POINT (4.624343 52.335009)
Oosterhout	2	8	0	OTH	POINT (4.86169 51.641022)
Zevenbergen	1	0	0	ZVG	POINT (4.6105971 51.6468)
Culemborg	1	0	0	CUB	POINT (5.215416 51.962137)
Delft	1	17	0	DFT	POINT (4.3774 51.9829)
Den Helder	6	14	1	DHR	POINT (4.776231 52.958323)
Dordrecht	52	88	11	DOR	POINT (4.729228 51.823862)
Dussen	2	1	0	DUS	POINT (4.981227 51.717769)

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Enkhuizen	11	9	0	ENK	POINT (5.27451 52.688697)
Etten Leur	1	0	0	ETT	POINT (4.6366700000000005 51.628544)
Europoort	1	1	1	EUR	POINT (4.18268 51.933767)
Gouderak	2	0	0	GDK	POINT (4.67288 51.985242)
Genderen	2	0	0	GND	POINT (5.049591 51.710484)
Goes	1	0	0	GOE	POINT (3.891247 51.511267)
Gorinchem	11	13	0	GOR	POINT (4.977 51.840545)
Gouda	3	30	0	GOU	POINT (4.711277 52.004965)
's-Gravendeel	3	6	2	GRA	POINT (4.619941 51.79087)
Groot-Ammers	7	0	0	GRO	POINT (4.815745 51.925448)
Geertruidenberg	1	0	0	GTB	POINT (4.84318 51.692098)
The Hague	2	0	0	HAG	POINT (4.344305 52.064031)
Harmelen	1	0	0	HAM	POINT (4.9564 52.089726)
Hansweert/Schore	6	9	0	HAN	POINT (4.012046 51.446043)
Haastrecht	2	0	0	HCH	POINT (4.773325 52.002019)
Hoofddorp	1	2	1	HFD	POINT (4.800426 52.302398)
Hendrik-Ido-Ambacht	3	1	0	HIA	POINT (4.673052 51.833861)
Hank	1	0	0	HNK	POINT (4.891927 51.719384)
Hoeven	1	0	0	HON	POINT (4.584193 51.627278)
Hoorn	2	0	0	HRN	POINT (5.063578 52.634623)
Boven-Hardinxveld	7	5	0	HRX	POINT (4.888916 51.82113)
Hellevoetsluis	1	0	0	HSL	POINT (4.132842 51.821743)
Hagestein	1	4	0	HSN	POINT (5.144751 51.978059)
Hoek van Holland	3	1	0	HVH	POINT (4.133408 51.972389)
IJmuiden/Velsen	39	43	0	IJM	POINT (4.630862 52.469585)
Kamperland	1	1	0	KAD	POINT (3.683183 51.557288)
Krimpen aan den IJssel	6	2	0	KAI	POINT (4.580398 51.911813)

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Kinderdijk	4	0	0	KIJ	POINT (4.619536 51.886921)
Klundert	2	7	0	KLU	POINT (4.526281 51.687042)
Kortgene	3	1	0	KOG	POINT (3.811328 51.55051)
Krommenie	2	0	0	KRM	POINT (4.7759920000000005 52.515766)
Krimpen aan de Lek	5	1	0	KRP	POINT (4.635037 51.889716)
Loenen aan de Vecht	5	2	1	LAV	POINT (4.9972639999999995 52.18945)
Leimuiden	2	6	0	LMU	POINT (4.648506 52.207883)
Lexmond	3	7	0	LXM	POINT (4.9667639999999995 51.958427)
Middelburg	3	0	0	MID	POINT (3.647734 51.501746)
Middelharnis	2	3	0	MIH	POINT (4.317498 51.753781)
Marken	1	0	0	MKN	POINT (5.085948 52.485453)
Moerdijk	47	41	10	MOE	POINT (4.5567329999999995 51.690179)
Maassluis	3	1	0	MSL	POINT (4.243314 51.911409)
Muiden	1	0	0	MUD	POINT (5.069585 52.334273)
Nieuwdorp	2	0	0	NIU	POINT (3.7195 51.4452)
Nieuw-Lekkerland	2	2	0	NLK	POINT (4.68421 51.894496)
Noordwijkerhout	1	0	0	NOJ	POINT (4.501831 52.248861)
Nieuwegein	2	32	0	NWG	POINT (5.097006 52.008274)
Ouderkerk aan den IJssel	4	0	0	OAI	POINT (4.644655 51.953201)
Oud-Beijerland	4	0	0	OBL	POINT (4.412363 51.829077)
Oudeschild	1	0	0	OHI	POINT (4.852969 53.041068)
Papendrecht	11	2	0	PAP	POINT (4.723491 51.822801)
Pernis	66	28	0	PER	POINT (4.39 51.88)
Sint Philipsland	3	4	1	PLP	POINT (4.172552 51.660658)
Puttershoek	3	1	0	PTK	POINT (4.577329 51.807218)
Elst	3	2	0	QCU	POINT (5.497198 51.980636)
Roelofarendsveen	2	4	0	RAV	POINT (4.6315100000000005 52.181872)

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Rhoon	1	0	0	RHO	POINT (4.423499 51.842319)
Ridderkerk	11	1	0	RID	POINT (4.62 51.87)
Rilland	2	0	0	RLA	POINT (4.21 51.36)
Rilland	2	7	1	RLA	POINT (4.21 51.36)
Roosendaal	1	0	0	ROO	POINT (4.454497 51.547845)
Rotterdam	700	701	16	RTM	POINT (4.31 51.87)
Schiedam	38	1	0	SCI	POINT (4.381914 51.902149)
Schoonhoven	1	1	0	SHH	POINT (4.853111 51.94226)
Schalkwijk	4	1	0	SKW	POINT (5.178595 51.967214)
Sliedrecht	1	2	0	SLD	POINT (4.7663709999999995 51.814793)
Sluiskil	19	2	0	SLU	POINT (3.840767 51.277651)
Spaarndam	2	0	0	SPD	POINT (4.698857 52.424291)
Spijkenisse	3	0	0	SPI	POINT (4.394703 51.830881)
Stellendam	2	2	0	STD	POINT (4.044212 51.821532)
Sas van Gent	37	5	2	SVG	POINT (3.802428 51.210478)
Tilburg	7	26	0	TLB	POINT (5.09955 51.57173)
Terneuzen	71	22	1	TNZ	POINT (3.841452 51.299803)
Uithoorn	2	6	1	UIT	POINT (4.839124 52.235308)
Utrecht	5	29	1	UTC	POINT (5.073642 52.109604)
Uitgeest	1	0	0	UTG	POINT (4.722488 52.529332)
Vianen	2	8	0	VAN	POINT (5.088075 52.001757)
Veere	4	4	1	VER	POINT (3.669965 51.550097)
Vlaardingen	16	12	0	VLA	POINT (4.355419 51.898907)
Vlissingen	56	3	0	VLI	POINT (3.7188179999999997 51.473634)
Voorhout	1	0	0	VOH	POINT (4.474058 52.230166)
Velsen-Noord	4	1	1	VSN	POINT (4.6452919999999995 52.46539)
West-Knollendam	2	2	0	WAM	POINT (4.792051 52.519579)
Wijk bij Duurstede	2	17	0	WBD	POINT (5.349628 51.970875)

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Woudrichem	2	0	0	WCM	POINT (5.00439 51.818635)
Westdorpe	9	3	0	WDP	POINT (3.8333 51.2686)
Wemeldinge	2	0	0	WED	POINT (4.006716 51.504376)
West-Graftdijk	2	0	0	WGD	POINT (4.832785 52.53938)
Wilhelminadorp	2	0	0	WHD	POINT (3.923407 51.537165)
Wieringerwerf	2	0	0	WIW	POINT (5.13074 52.865502)
Werkendam	3	8	0	WKD	POINT (4.872556 51.778989)
Waalwijk	3	2	0	WLK	POINT (5.057504 51.697621)
Wormer	1	1	0	WMO	POINT (4.795327 52.495943)
Woerden	1	0	0	WOR	POINT (4.86877 52.084378)
Waspik	2	0	0	WPI	POINT (4.918827 51.711132)
Westzaan	1	0	0	WTZ	POINT (4.754988 52.4309)
Zaandam	20	46	0	ZAA	POINT (4.816101 52.426323)
Zaandijk	1	0	0	ZAD	POINT (4.810366 52.485686)
Nederhemert	1	0	0	ZBA	POINT (5.13589 51.761204)
Nijnsel	1	4	0	ZBG	POINT (4.608588 51.655545)
Zuid-Beijerland	2	0	0	ZBJ	POINT (4.321989 51.743147)
Zierikzee	1	0	0	ZIE	POINT (3.918114 51.646128)
Zuidland	1	0	0	ZUL	POINT (4.2831019999999995 51.80479)
Zwijndrecht	25	7	1	ZWI	POINT (4.610696 51.802026)

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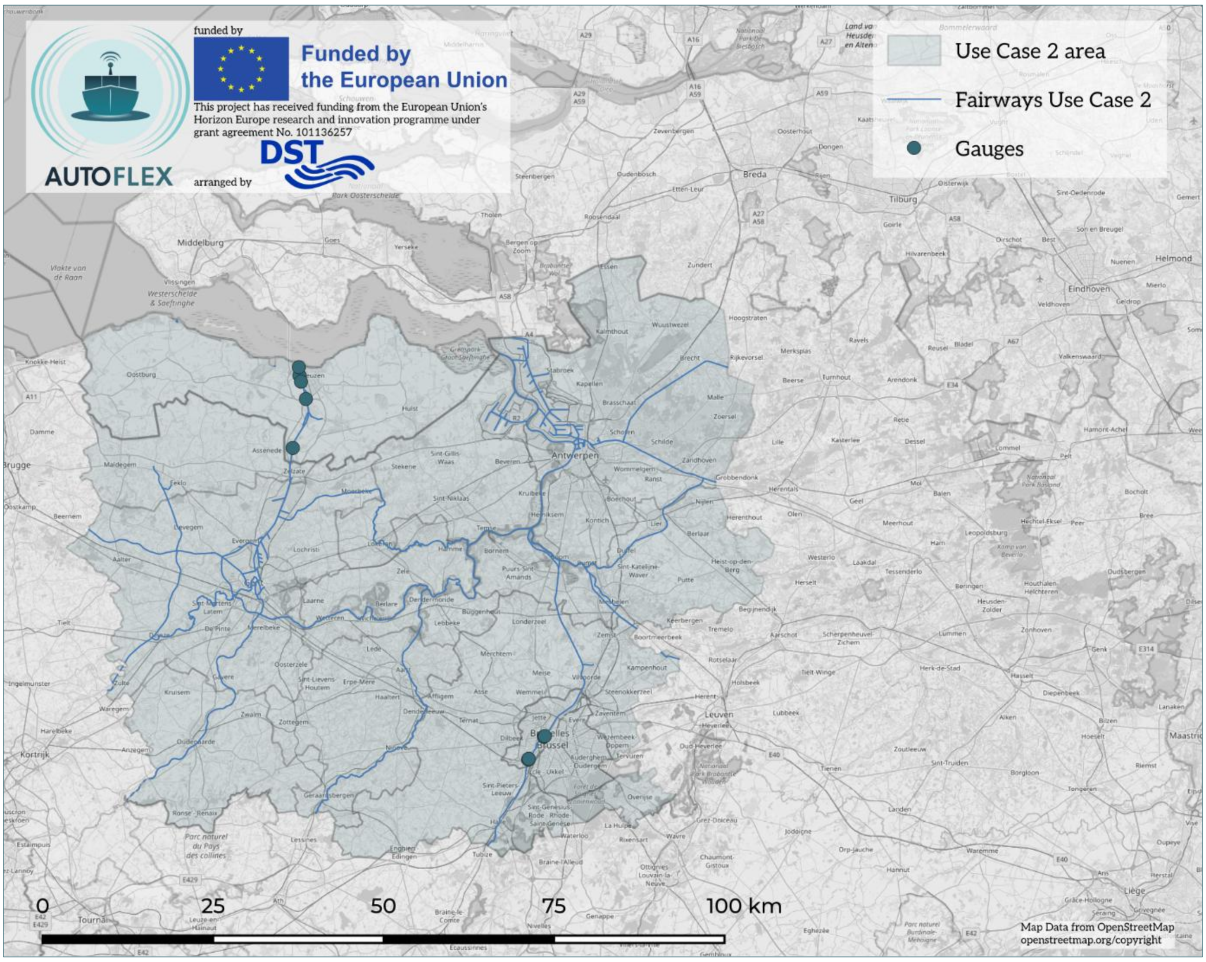

Figure A-2: Gauges in the Use Case 2 area

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Table A-3: Port cities (including number of assigned terminals and berths) in the Use Case 2 area

Name	Number of terminals	Number of berths	Number of transshipment berths	UN/ LOCODE	Geo-coordinates
Aalst	9	14	9	AAB	POINT (4.041331 50.943675999999996)
Aalter	4	4	4	AAL	POINT (3.450475 51.109247)
Anderlecht/Brussel (Bruxelles)	6	24	7	ANL	POINT (4.317398473 50.833485346)
Antwerpen	129	795	645	ANR	POINT (4.364993 51.279115)
Beveren	2		2	BEV	POINT (4.302828 51.272275)
Boom	1	3	1	BOM	POINT (4.356931 51.087418)
Bornem	1	6	1	BON	POINT (4.316394 51.099182)
Brecht	1	22	1	BRC	POINT (4.679902 51.343374)
Brussel (Bruxelles)	31	71	35	BRU	POINT (4.387005 50.886442)
Deinze	8	9	8	DDR	POINT (4.082362 51.042451)
Dendermonde	5	10	5	DEZ	POINT (3.520393 50.986599)
Duffel	1	2	1	DUF	POINT (4.485042 51.081055)
Evergem	4	31	4	EVM	POINT (3.696937 51.099034)
Gavere	3	7	3	GEA	POINT (3.879843 50.765524)
Gent (Ghent)	95	326	247	GNE	POINT (3.735172 51.093488)
Geraardsbergen	1	13	1	GVR	POINT (3.651265 50.935181)
Grimbergen	10	12	10	HLL	POINT (4.23454 50.73385)
Halle	2	11	2	ECH	POINT (4.470674 51.03312)
Hemiksem	2	3	2	GRB	POINT (4.413659 50.937115)
Kampenhout	2	5	2	HEX	POINT (4.33338 51.15504)
Kapelle-op-den-Bos	1	4	1	KEK	POINT (4.324639 51.182843)
Kluisbergen	4	6	4	KMH	POINT (4.595823 50.955708)
Kruibeke	1	5	1	KPB	POINT (4.364562 51.01005)
Lier	4	6	4	KSR	POINT (3.488742 50.785169)
Lovendegem	1	2	1	LIE	POINT (4.592057 51.129571)

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Mechelen	1	17	1	LVO	POINT (3.644765 51.092376)
Nazareth	1	1	1	NIL	POINT (4.325367 51.104482)
Niel	1	3	2	NZH	POINT (3.656314 50.956442)
Oudenaarde	5	13	5	OUD	POINT (3.584499 50.827219)
Puurs	9	13	9	PUU	POINT (4.35313 51.08483)
Ranst	2	2	2	RAS	POINT (4.588043 51.210284)
Rilland	2	7	0	RLA	POINT (4.21 51.36)
Rumst	2	2	2	RUS	POINT (4.418328 51.078702)
Sas van Gent	1	5	0	SVG	POINT (3.802428 51.210478)
Sas van Gent	37	5	2	SVG	POINT (3.802428 51.210478)
Schilde	1	2	1	SCE	POINT (4.5488800000000005 51.222841)
Schoten	13	36	13	SCT	POINT (4.467933 51.239804)
Sint-Pieters-Leeuw	3	12	3	SPT	POINT (4.258565 50.757021)
Sluiskil	19	2	0	SLU	POINT (3.840767 51.277651)
Temse	2	5	2	TSE	POINT (4.226418 51.1222)
Terneuzen	71	22	1	TNZ	POINT (3.841452 51.299803)
Vilvoorde	2	6	2	VIL	POINT (4.420596 50.921836)
Westdorpe	9	3	0	WDP	POINT (3.8333 51.2686)
Wijnegem	4	16	4	WJG	POINT (4.547662 51.223229)
Willebroek	9	23	10	WLB	POINT (4.359302 51.040614)
Wommelgem	2	3	2	WMM	POINT (4.553727 51.221233)
Zandhoven	6	8	6	ZAN	POINT (4.645616 51.196436)
Zele	1	1	1	ZEL	POINT (3.804891 51.21165)
Zelzate	3	19	7	ZET	POINT (4.384524 50.98697)
Zemst	1	1	1	ZLE	POINT (4.059474 51.049252)
Zulte	2	3	1	ZUL	POINT (3.502805 50.97566)
Zwijndrecht	6	10	5	ZWL	POINT (4.333874 51.195387)

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2023	Container load (road) in the Use Case 1 and Use Case 2 areas (tons)																				
load ↓ unload □	BE100	BE211	BE212	BE231	BE232	BE233	BE234	BE235	BE236	BE241	NL310	NL33A	NL332	NL333	NL337	NL33B	NL33C	NL324	NL329	NL411	Total
BE100	0	0	0	0	0	0	0	0	0	0	2.486	8.046	0	1.937	0	769	5.582	0	7.772	1.264	26.592
BE211	0	0	0	0	0	0	0	0	0	0	54.699	83.479	10.770	16.805	16.460	16.791	248.184	6.027	31.875	253.513	485.090
BE212	0	0	0	0	0	0	0	0	0	0	8.118	10.201	9.773	2.393	1.412	7.985	24.179	0	3.414	9.974	67.476
BE231	0	0	0	0	0	0	0	0	0	0	4.551	6.072	0	6.004	0	261	9.533	0	942	11.779	27.364
BE232	0	0	0	0	0	0	0	0	0	0	325	1.131	0	73	261	244	6.171	10	1.109	4.117	9.324
BE233	0	0	0	0	0	0	0	0	0	0	231	0	0	0	229	0	6.025	0	0	7.631	6.484
BE234	0	0	0	0	0	0	0	0	0	0	19.509	9.760	2.413	4.273	2.082	2.330	31.920	0	2.343	37.346	74.630
BE235	0	0	0	0	0	0	0	0	0	0	548	2.118	0	241	0	0	1.902	0	2.942	3.972	7.752
BE236	0	0	0	0	0	0	0	0	0	0	8.847	8.013	4.344	1.807	2.153	684	34.114	0	11.459	48.841	71.421
BE241	0	0	0	0	0	0	0	0	0	0	4.041	8.345	501	1.489	2.562	495	6.534	0	9.203	10.740	33.168
NL310	12.550	35.526	8.948	1.418	1.915	3.490	16.308	5.906	6.119	6.311	3.106.642	197.293	139.921	101.592	278.118	277.522	518.667	23.393	485.141	263.714	5.226.780
NL33A	431	38.074	3.858	3.816	8.807	98	19.217	233	11.115	4.568	130.581	955.307	32.895	36.844	85.648	91.588	826.957	3.489	77.893	187.684	2.331.419
NL332	511	1.087	707	142	0	0	40	145	227	1.873	94.478	35.808	670.335	239.087	96.404	82.035	440.884	2.190	102.685	100.470	1.768.638
NL333	4.501	4.016	3.885	625	29	0	7.845	0	1.955	135	56.904	26.070	69.707	723.470	108.194	64.974	713.816	857	237.625	111.224	2.024.607
NL337	12	5.742	519	327	712	0	2.103	0	1.024	3.760	94.885	20.773	135.630	81.926	610.892	426.963	227.889	45.599	303.143	90.708	1.961.900
NL33B	4.288	15.855	4.076	1.712	1.180	135	2.594	372	3.285	17.604	278.415	128.041	157.824	52.660	276.335	605.265	502.186	4.118	144.523	272.499	2.200.468
NL33C	31.250	237.407	25.972	2.923	6.037	2.726	18.313	3.635	46.698	27.964	640.239	639.666	554.981	1.071.187	257.835	585.062	9.244.808	11.631	597.860	1.384.484	14.006.190
NL324	0	12.089	0	0	0	0	0	0	0	0	6.430	2.481	3.855	863	8.176	1.194	5.026	63.386	143.103	8.557	246.602
NL329	0	17.306	638	3.492	45	0	12.494	184	3.980	14.559	339.864	62.796	106.331	245.463	463.838	158.404	465.074	198.638	3.923.315	274.617	6.016.421
NL411	15.318	263.951	25.077	3.989	3.189	8.392	63.793	3.421	36.025	25.365	418.734	369.727	69.576	154.685	220.505	135.923	1.302.806	32.380	181.960	3.585.252	3.334.815
Total	53.542	367.102	48.601	14.454	18.725	6.449	78.915	10.476	74.405	76.773	4.851.794	2.205.400	1.899.279	2.588.115	2.210.597	2.322.566	13.319.448	359.338	6.086.348	3.083.133	36.592.328

Figure A-3: Volumes of containerised cargo in road transport in the Use Case 1 and Use Case 2 areas in 2023 (enlarged version)

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Table A-4: Extended travel itinerary of transport route no. 1 from Den Haag to Oudenbosch

Transport route no. 1 from Den Haag to Oudenbosch	
Name of consignor (origin)	Provider of industrial equipment
Pre-haul distance to terminal of origin (road)	0.9 km
Name of consignee (destination)	Machines and components for the food industry
Post-haul distance from terminal of destination (road)	6.7 km
Name of terminal of origin*	's-Gravenhage, Basal
ISRS of terminal of origin*	NLHAG1250A0HAG200005
Type of terminal of origin*	Bulk terminal
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker : n/a
Name of terminal of destination*	WSV Nolleke Sas
ISRS of terminal of destination*	NLHON0012600HON00189
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker : false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1
Travelled CEMT classes (inland waterways)*	II, IV, V a, VI b, VI c
Number of locks passed*	3
Number of bridge constructions passed	***40*** (for details, please see Table A-5)
Total distance travelled*	98.07 km
Total travel time*	***0 d, 14 h and 49 min***
Avg. speed upstream*	***12.67 km/h***
Avg. speed downstream*	***12.67 km/h***

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL1250A00000	II	36.51	False	5.0	5.0
NL0125000036	II	343.58	False	7.0	7.0
NL0201B00000	II	810.74	False	7.0	7.0
NL0020103105	II	1426.79	False	7.0	7.0
NL0020103247	II	2656.96	False	7.0	7.0
NL0020103513	II	2728.63	False	7.0	7.0
NL0020103786	II	886.41	False	7.0	7.0
NL0020103875	II	6753.43	False	7.0	7.0

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NL0201T00000	II	968.15	False	7.0	7.0
NL0020104670	II	717.26	False	7.0	7.0
NL0020104742	II	225.02	False	7.0	7.0
NL0020104764	II	208.99	False	7.0	7.0
NL0020104785	II	216.57	False	7.0	7.0
NL0020104807	II	254.29	False	7.0	7.0
NL0020104832	II	121.09	False	7.0	7.0
NL0020104845	II	2229.86	False	7.0	7.0
NL0020105068	II	101.05	False	7.0	7.0
NL0020105078	II	978.49	False	7.0	7.0
NL0020105175	II	879.77	False	7.0	7.0
NL0010201299	VIc	93.95	True	17.0	17.0
NL0010201213	VIc	854.44	True	13.0	13.0
NL0010201195	VIc	181.3	True	13.0	13.0
NL0010201155	VIc	404.37	True	13.0	13.0
NL0102C00122	VIc	640.56	True	13.0	13.0
NL0102C00101	VIc	216.5	True	13.0	13.0
NL0102C00000	VIc	1013.16	True	13.0	13.0
NL0010200793	VIc	1639.79	True	13.0	13.0
NL0010200733	VIc	603.66	True	17.0	17.0
NL0010200543	VIc	1897.72	True	17.0	17.0
NL0010200533	VIc	97.75	True	17.0	17.0
NL0010200499	VIc	345.65	True	17.0	17.0
NL0010200484	VIc	147.95	True	17.0	17.0
NL0010200349	VIc	1349.28	True	17.0	17.0
NL0010200308	VIc	409.1	True	17.0	17.0
NL0010200000	VIc	3085.88	True	17.0	17.0
NL0010112476	VIc	1662.4	True	17.0	17.0
NL0010112244	VIc	2326.65	True	17.0	17.0
NL0010112125	VIc	1190.03	True	17.0	17.0
NL0101C00000	Va	2613.26	True	12.0	12.0
NL0010111768	VIc	818.05	True	17.0	17.0
NL0011100000	VIc	103.9	True	13.0	13.0
NL0011100010	VIc	170.88	True	13.0	13.0
NL0011100027	VIc	743.13	True	13.0	13.0
NL0011100101	VIc	205.97	True	13.0	13.0
NL0011100122	VIc	62.25	True	13.0	13.0
NL0011100128	VIc	404.59	True	13.0	13.0
NL0011100169	VIc	1044.72	True	13.0	13.0
NL0011100273	VIc	582.53	True	13.0	13.0

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NL0011100331	VIc	405.26	True	13.0	13.0
NL0011100372	VIc	78.01	True	13.0	13.0
NL0011100380	VIc	519.96	True	13.0	13.0
NL0011200881	VIc	918.26	True	17.0	17.0
NL0011200776	VIc	1055.57	True	17.0	17.0
NL0011200521	VIc	2549.48	True	17.0	17.0
NL0011200070	VIc	4511.21	True	17.0	17.0
NL0011200000	VIc	701.81	True	17.0	17.0
NL0010802387	VIc	8484.11	True	17.0	17.0
NL0010803235	VIc	3899.55	True	17.0	17.0
NL0010803625	VIc	401.29	True	17.0	17.0
NL0010803665	VIc	454.69	True	17.0	17.0
NL0014300000	VIb	476.63	True	17.0	17.0
NL0014300047	VIb	3347.78	False	17.0	17.0
NL0014300382	VIb	415.04	False	17.0	17.0
NL0014300424	VIb	2513.26	False	17.0	17.0
NL0012603806	Va	716.89	False	12.0	12.0
NL0012603786	Va	194.68	False	12.0	12.0
NL0012603223	Va	5632.58	False	10.0	10.0
NL0012603124	IV	986.76	False	10.0	10.0
NL0012602777	IV	3479.35	False	10.0	10.0
NL0012602468	IV	3084.42	False	10.0	10.0
NL0012601885	IV	5829.41	False	8.0	8.0
NL0012601584	IV	0.0	False	8.0	8.0

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Table A-5: Locks and bridges (with fixed or movable bridge openings) along transport route no. 1 from Den Haag to Oudenbosch

Lock	Bridge	allowed height (open)	allowed height (closed)	allowed clearance width
	Binckhorstbrug	no limitation	3.43 m	6.50 m
	Geestbrug	no limitation	2.65 m	10.26 m
	Hoornbrug	no limitation	3.93 m	10.32 m
	De Oversteek	no limitation	3.13 m	20.87 m
	Het Fortuin	[*fixed bridge*]	6.96 m	11.70 m
	Reineveldbrug	no limitation	4.33 m	9.72 m
	Plantagebrug	no limitation	2.83 m	10.23 m
	Koepoortbrug	no limitation	2.46 m	10.02 m
	Oostpoortbrug	no limitation	1.39 m	15.47 m
	Sint-Sebastiaansbrug	no limitation	4.62 m	10.46 m
	Hambrug	no limitation	1.28 m	10.49 m
	Abtswoudsebrug	no limitation	1.35 m	10.46 m
	Kruithuisbrug	no limitation	5.47 m	10.40 m
	Kandelaarbrug	no limitation	4.26 m	10.28 m
	Doenbrug	no limitation	7.43 m	10.50 m
	Hogebrug, Rotterdam	no limitation	2.32 m	7.55 m
	Spaansebrug	no limitation	3.88 m	10.45 m
	Giessenbrug	no limitation	5.43 m	10.70 m
	Hoge Delfshavensche Schiespoorbrug	no limitation	6.83 m	10.00 m
	Beukelsbrug	no limitation	5.50 m	10.40 m
	Mathenesserbrug	no limitation	4.03 m	8.00 m
	Lage Erfbrug	no limitation	3.58 m	13.60 m
	Pieter de Hoochbrug	no limitation	4.53 m	13.20 m
	Coolhavenbrug	no limitation	3.78 m	13.65 m
Parksluizen [two chambers: *kleine kolk Parksluizen* (125 m x 5.95 m), *grote kolk Parksluizen* (128 m x 13.55 m)]				
	Parkhavenbrug	no limitation	1.62 m	13.65 m

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	Erasmusbrug	no limitation	1.28 m	50.12 m
	Koninginnebrug, Rotterdam	no limitation		49.34 m
	De Hef, brug	43.98 m	5.78 m	50.14 m
	Van Brienenoordbrug	no limitation	22.64 m	50.00 m
	Alblasserdamsebrug	no limitation	10.48 m	43.00 m
	Grotebrug, spoorbrug	44.57 m	9.48 m	66.00 m
	Dordrecht, verkeersbrug	no limitation	9.74 m	66.00 m
Volkeraksluizen [three chambers: *middenkolk Volkeraksluizen* (308.90 m x 24.10 m), *westkolk Volkeraksluizen* (327 m x 24 m), *oostkolk Volkeraksluizen* (331.50 m x 24.10 m)]				
	Volkeraksluizen, brug over benedenhoofd	34.01 m	14.56 m	24.10 m
Mandersssluis [one chamber: *Mandersssluis* (115 m x 12 m)]				
	Prinsenlandsebrug	no limitation	2.80 m	14.10 m
	Zoombruggen	[*fixed bridge*]	10.00 m	34.90 m
	Brug in de N268	[*fixed bridge*]	7.00 m	48.50 m
	Brug in de A17 Standdaardbuiten	[*fixed bridge*]	7.00 m	18.75 m
	Brug in de Marktweg Standdaarbuiten	[*fixed bridge*]	7.00 m	28.00 m
	Lamgatse fietsbrug	[*fixed bridge*]	7.00 m	45.00 m
	Markspoorbrug Zevenbergen	7.00 m	2.50 m	9.10 m

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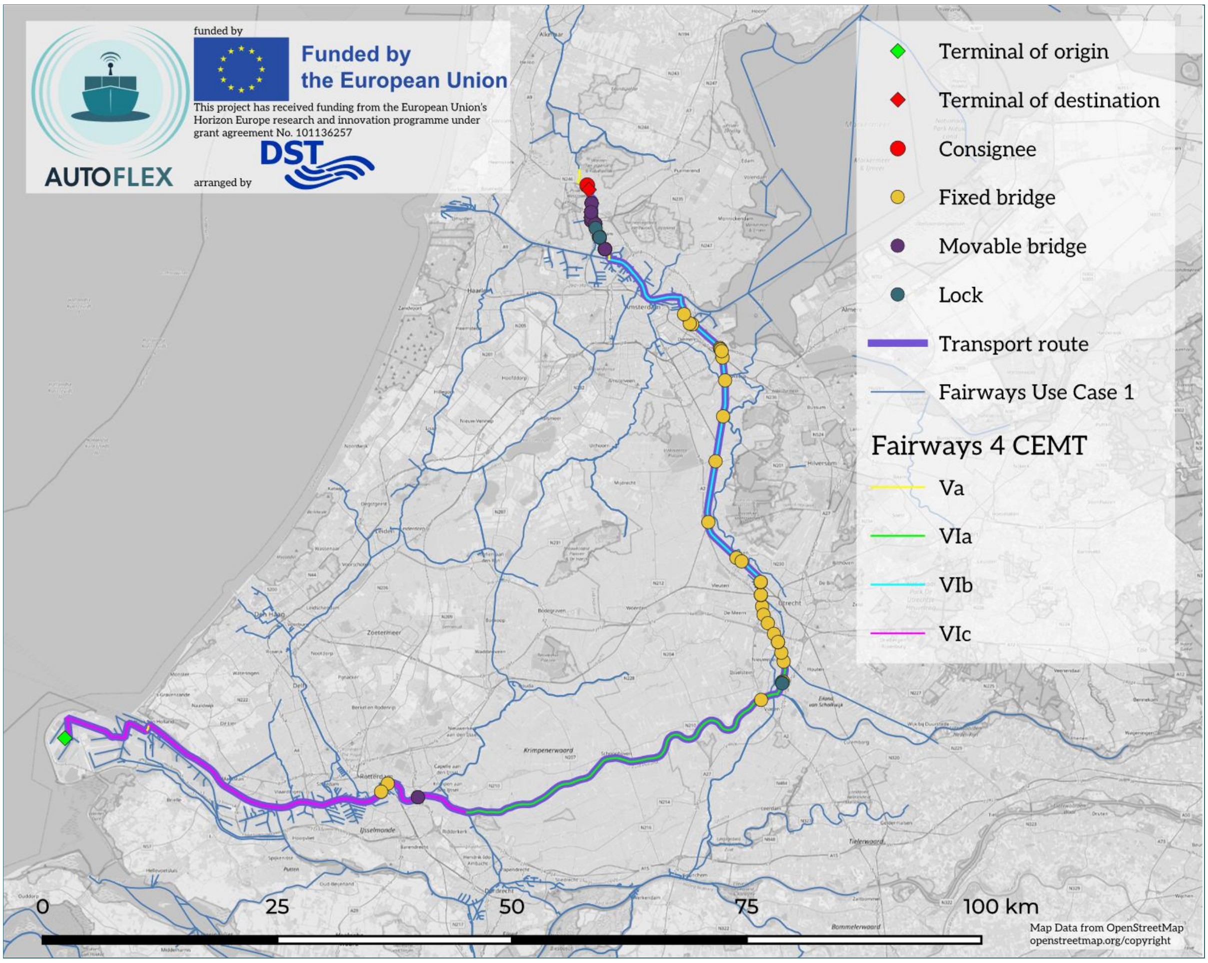

Figure A-4: Exemplary transport route no. 4 (variant) from Rotterdam to Wormerveer (Zaanstad)

Table A-6: Travel itinerary of transport route no. 4 (variant) from Rotterdam to Wormerveer (Zaanstad)

Transport route no. 4 (variant) from Rotterdam to Wormerveer (Zaanstad)	
Name of seaport (origin)	Port of Rotterdam
Pre-haul distance to terminal of origin (road)	0 km
Name of consignee (destination)	Food manufacturer
Post-haul distance from terminal of destination (road)	2.6 km
Name of terminal of origin*	RWG - ROTTERDAM WORLD GATEWAY
ISRS of terminal of origin*	NLRTM0126200RWG00014
Type of terminal of origin*	Container terminal
Availability of container transshipment facilities at terminal of origin	Container crane: true Mobile harbour crane: true Reach stacker: true
Name of terminal of destination*	LODERS CROKLAAN
ISRS of terminal of destination*	NLZAD0023600LOD00087
Type of terminal of destination*	Bulk terminal

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Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	IV
Container layer(s)	2

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL0010202037	VIc	630	true	13	13
NL0010202007	VIc	307	true	13	13
NL0010202139	VIc	891	true	13	13
NL0010202100	VIc	390	true	13	13
NL0102M00000	Va	803	true	12	12
NL0011601268	VIc	2151	true	17	17
NL0023302526	VIb	630	false	17	17
NL0022504196	VIb	1139	false	17	17
NL0010200999	VIc	1341	true	13	13
NL0010200957	VIc	416	true	13	13
NL0225E00309	VIa	1086	false	12	12
NL0010200793	VIc	1640	true	13	13
NL0010200733	VIc	604	true	17	17
NL0010200499	VIc	346	true	17	17
NL0010200543	VIc	1898	true	17	17
NL0010200533	VIc	98	true	17	17
NL0010310797	VIa	7466	true	15	17
NL0010200349	VIc	1349	true	17	17
NL0010200308	VIc	409	true	17	17
NL0010202922	VIc	7111	true	12	12
NL0225E00000	VIa	3092	false	12	12
NL0010200484	VIc	148	true	17	17
NL0022502556	VIb	6610	false	17	17
NL0022500000	VIb	602	false	17	17
NL0022500060	VIb	250	false	17	17
NL0022500095	VIb	636	false	17	17
NL0022500085	VIb	100	false	17	17
NL0010309310	VIa	9052	true	15	17
NL0010200000	VIc	3086	true	17	17

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NL0010202229	VIc	1026	true	13	13
NL0010310215	VIa	5822	true	15	17
NL0010202354	VIc	701	true	13	13
NL0022502228	VIb	3279	false	17	17
NL0010202331	VIc	233	true	13	13
NL0010202425	VIc	4970	true	12	12
NL0022500726	VIb	3306	false	17	17
NL0022500158	VIb	5679	false	17	17
NL0115600000	VIc	365	true	5	5
NL0115600036	VIc	1024	true	9	9
NL0126500000	VIc	2193	true	9	9
NL0023302059	VIb	1420	false	17	17
NL0023302239	VIb	198	false	17	17
NL0023302221	VIb	187	false	17	17
NL0023302214	VIb	70	false	17	17
NL0023302201	VIb	125	false	17	17
NL0023302259	VIb	415	false	17	17
NL0023302319	VIb	1322	false	17	17
NL0023302301	VIb	189	false	17	17
NL0023302452	VIb	748	false	17	17
NL0023600160	Va	673	false	12	12
NL0023301615	VIb	1112	false	17	17
NL0023600108	Va	525	false	12	12
NL0023600000	Va	290	false	12	12
NL0023600029	Va	134	false	12	12
NL0023600042	Va	656	false	12	12
NL0023301727	VIb	873	false	17	17
NL0023301827	VIb	349	false	17	17
NL0023301814	VIb	134	false	17	17
NL0023600362	Va	1143	false	12	12
NL0010201899	VIc	289	true	13	13
NL0010201821	VIc	10	true	17	17
NL0010201822	VIc	765	true	13	13
NL0023301875	VIb	440	false	17	17
NL0023301862	VIb	128	false	17	17
NL0023301919	VIb	1401	false	17	17
NL0023600278	Va	833	false	12	12

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NL0023600227	Va	510	false	12	12
NL0010201928	VIc	790	true	13	13
NL0022503621	VIb	1605	false	17	17
NL0010201591	VIc	186	true	13	13
NL0022501057	VIb	2902	false	17	17
NL0010201685	VIc	192	true	13	13
NL0010201631	VIc	538	true	13	13
NL0010201610	VIc	208	true	13	13
NL0022503781	VIb	4150	false	17	17
NL0010201766	VIc	549	true	13	13
NL0010201713	VIc	534	true	13	13
NL0010201704	VIc	93	true	13	13
NL0023600476	Va	1712	false	12	12
NL0010201354	VIc	243	true	13	13
NL0010201378	VIc	450	true	13	13
NL0010201423	VIc	190	true	13	13
NL0010201442	VIc	38	true	17	17
NL0010201446	VIc	998	true	13	13
NL0010308162	VIa	11475	true	15	17
NL0022501347	VIb	8807	false	17	17
NL0010201553	VIc	381	true	13	13
NL0010201546	VIc	75	true	17	17
NL0023600647	Va	5108	false	12	12
NL0010201195	VIc	181	true	13	13
NL0116A00034	VIc	777	true	17	17
NL0010201155	VIc	404	true	13	13
NL0022503217	VIb	2896	false	17	17
NL0126000000	VIc	5234	true	9	9
NL0010201133	VIc	218	true	13	13
NL0010201213	VIc	854	true	13	13
NL0116A00112	VIc	472	true	17	17
NL0010308139	VIa	233	true	15	17
NL0010201299	VIc	94	true	17	17
NL0010201308	VIc	301	true	13	13
NL0010201338	VIc	156	true	13	13
NL0116A00000	VIc	346	true	17	17
NL0010308081	VIa	580	true	15	17

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NL0010203633	VIc	3620	true	12	12
NL0010311569	VIa	4681	true	15	17
NL0010311544	VIa	257	true	15	17
NL0022503521	VIb	532	false	17	17
NL0022503506	VIb	150	false	17	17
NL0022503574	VIb	465	false	17	17

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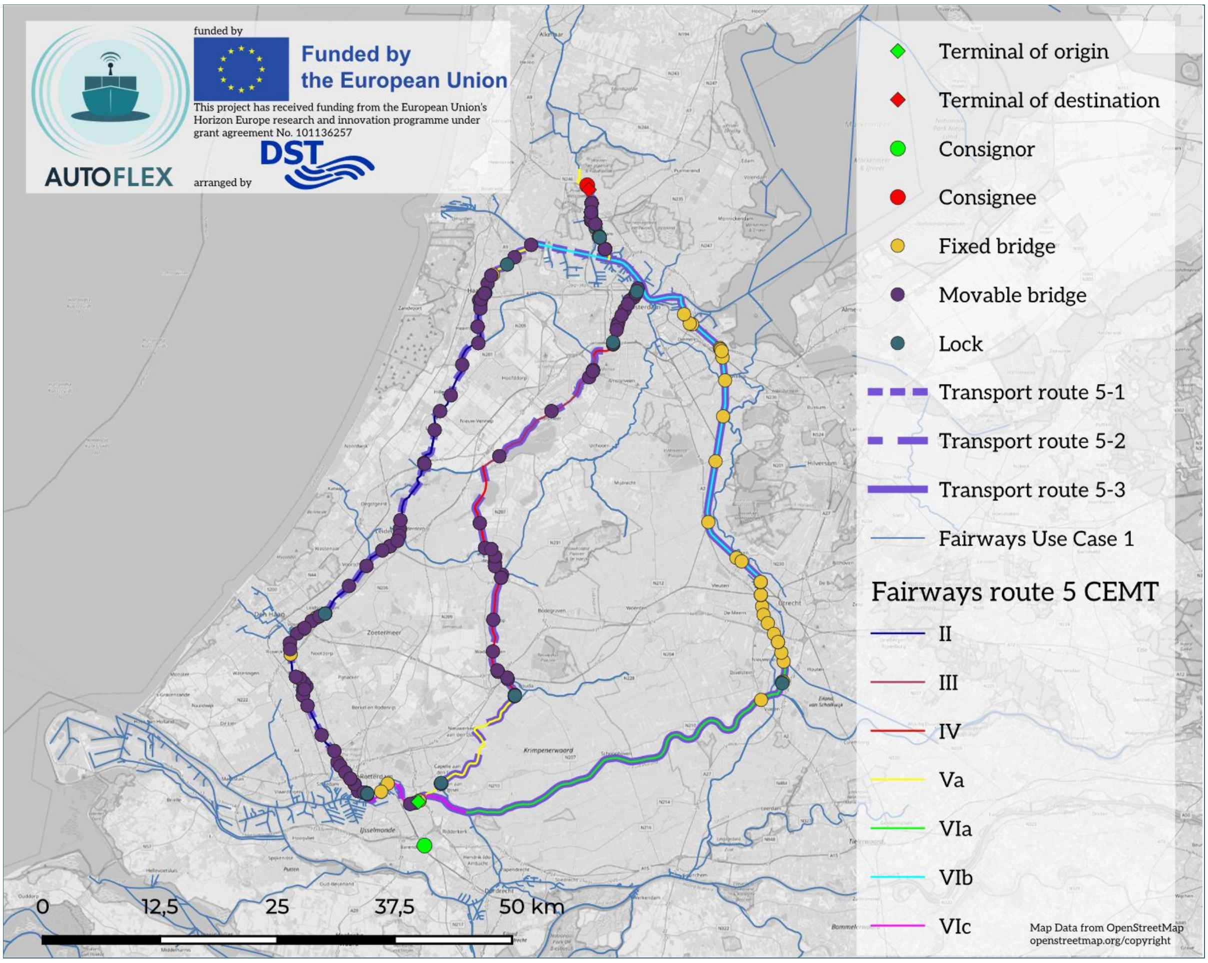

Figure A-5: Exemplary transport routes nos. 5a, 5b, and 5c from Barendrecht to Wormerveer (Zaanstad)

Table A-7: Travel itinerary of transport route no. 5a from Barendrecht to Wormerveer (Zaanstad)

Transport route no. 5a from Barendrecht to Wormerveer (Zaanstad)	
Name of consignor (origin)	Food processing company
Pre-haul distance to terminal of origin (road)	6.5 km
Name of consignee (destination)	Food manufacturer
Post-haul distance from terminal of destination (road)	2.6 km
Name of terminal of origin*	ZUIDDIEPJE PONTMEYER ROTTERDAM
ISRS of terminal of origin*	NLRTM0102BZDPMR00009
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker: false
Name of terminal of destination*	LODERS CROKLAAN
ISRS of terminal of destination*	NLZAD0023600LOD00087
Type of terminal of destination*	Bulk terminal

Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	**CEMT class (fairway)***	**Length* [m]**	**Tide-dependency***	**Max. speed upstream* [km/h]**	**Max. speed downstream* [km/h]**
NL0023300788	VIb	1733	false	17	17
NL0023300788	VIb	1733	false	17	17
NL0023301118	VIb	986	false	17	17
NL0023301217	VIb	1594	false	17	17
NL0023300788	VIb	1733	false	17	17
NL0023300961	VIb	265	false	17	17
NL0023300987	VIb	1308	false	17	17
NL0020200000	Va	3795	false	12	12
NL0020200000	Va	3795	false	12	12
NL0020200379	Va	543	false	12	12
NL0020200945	II	2965	false	7	7
NL0020200801	Va	157	false	7	7
NL0020200817	II	1279	false	7	7
NL0020200433	Va	3203	false	12	12
NL0020200754	Va	478	false	12	12
NL0020201403	II	101	false	7	7
NL0020201242	II	1618	false	7	7
NL0020201403	II	101	false	7	7
NL0020201413	II	7299	false	7	7
NL0023301419	VIb	1963	false	17	17
NL0023301376	VIb	428	false	17	17
NL0023600108	Va	525	false	12	12
NL0023600160	Va	673	false	12	12
NL0023600227	Va	510	false	12	12
NL0023600278	Va	833	false	12	12
NL0023600000	Va	290	false	12	12
NL0023600029	Va	134	false	12	12
NL0023600042	Va	656	false	12	12
NL0023600647	Va	5108	false	12	12

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NL0023600362	Va	1143	false	12	12
NL0023600476	Va	1712	false	12	12
NL0023600000	Va	290	false	12	12
NL0020202600	II	4048	false	7	7
NL0020202345	II	2552	false	7	7
NL0020202143	II	2018	false	7	7
NL0020202600	II	4048	false	7	7
NL0020100628	II	507	false	7	7
NL0020100678	II	169	false	7	7
NL0020101987	II	11181	false	7	7
NL0020101876	II	1110	false	7	7
NL0020103105	II	1427	false	7	7
NL0020103247	II	2657	false	7	7
NL0020103786	II	886	false	7	7
NL0020103875	II	6753	false	7	7
NL0020103513	II	2728	false	7	7
NL0020103247	II	2657	false	7	7
NL0020101987	II	11181	false	7	7
NL0020101544	II	2035	false	7	7
NL0020101748	II	1281	false	7	7
NL0020101876	II	1110	false	7	7
NL0020101470	II	736	false	7	7
NL0020101415	II	552	false	7	7
NL0020101064	II	3515	false	7	7
NL0020103875	II	6753	false	7	7
NL0020101016	II	475	false	7	7
NL0020100695	II	219	false	7	7
NL0020100826	II	146	false	7	7
NL0020100805	II	218	false	7	7
NL0020100783	II	219	false	7	7
NL0020100717	II	655	false	7	7
NL0020100948	II	136	false	7	7
NL0020100896	II	519	false	7	7
NL0020100856	II	402	false	7	7
NL0020100841	II	146	false	7	7
NL0020100961	II	549	false	7	7
NL0102B00000	III	2387	true	8	8

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NL0020104670	II	717	false	7	7
NL0020104785	II	217	false	7	7
NL0020104764	II	209	false	7	7
NL0020104742	II	225	false	7	7
NL0020104845	II	2230	false	7	7
NL0020104832	II	121	false	7	7
NL0020104807	II	254	false	7	7
NL0020105078	II	978	false	7	7
NL0020105068	II	101	false	7	7
NL0020105175	II	880	false	7	7
NL0201T00000	II	968	false	7	7
NL0010200999	VIc	1341	true	13	13
NL0010200957	VIc	416	true	13	13
NL0010200793	VIc	1640	true	13	13
NL0010200733	VIc	604	true	17	17
NL0010201133	VIc	218	true	13	13
NL0010201195	VIc	181	true	13	13
NL0010201155	VIc	404	true	13	13
NL0010201213	VIc	854	true	13	13
NL0010201299	VIc	94	true	17	17

Table A-8: Travel itinerary of transport route no. 5b from Barendrecht to Wormerveer (Zaanstad)

Transport route no. 5b from Barendrecht to Wormerveer (Zaanstad)	
Name of consignor (origin)	Food processing company
Pre-haul distance to terminal of origin (road)	6.5 km
Name of consignee (destination)	Food manufacturer
Post-haul distance from terminal of destination (road)	2.6 km
Name of terminal of origin*	ZUIDDIEPJE PONTMEYER ROTTERDAM
ISRS of terminal of origin*	NLRTM0102BZDPMR00009
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker: false
Name of terminal of destination*	LODERS CROKLAAN
ISRS of terminal of destination*	NLZAD0023600LOD00087
Type of terminal of destination*	Bulk terminal

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Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0021200998	III	n/a	false	10	10
NL0023301615	VIb	n/a	false	17	17
NL0023600108	Va	n/a	false	12	12
NL0023600160	Va	n/a	false	12	12
NL0023600227	Va	n/a	false	12	12
NL0023600278	Va	n/a	false	12	12
NL0023600000	Va	n/a	false	12	12
NL0023600029	Va	n/a	false	12	12
NL0023600042	Va	n/a	false	12	12
NL0023600647	Va	n/a	false	12	12
NL0023600362	Va	n/a	false	12	12
NL0023600476	Va	n/a	false	12	12
NL0023600000	Va	n/a	false	12	12
NL0023301862	VIb	n/a	false	17	17
NL0023301875	VIb	n/a	false	17	17
NL0023301919	VIb	n/a	false	17	17
NL0021200000	IV	n/a	false	10	10
NL0023301814	VIb	n/a	false	17	17
NL0023301727	VIb	n/a	false	17	17
NL0021200311	IV	n/a	false	10	10
NL0021200319	IV	n/a	false	10	10
NL0021200448	IV	n/a	false	10	10
NL0021200423	IV	n/a	false	10	10
NL0021202785	IV	n/a	false	10	10
NL0021200125	IV	n/a	false	10	10
NL0021200141	IV	n/a	false	10	10
NL0021200156	IV	n/a	false	10	10
NL0021200171	IV	n/a	false	10	10
NL0021200270	IV	n/a	false	10	10

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NL0021200211	IV	n/a	false	10	10
NL0021200748	IV	n/a	false	10	10
NL0021200508	IV	n/a	false	10	10
NL0021200671	IV	n/a	false	10	10
NL0021200678	IV	n/a	false	10	10
NL0023301827	VIb	n/a	false	17	17
NL0021200028	IV	n/a	false	10	10
NL0021200080	IV	n/a	false	10	10
NL0021200090	IV	n/a	false	10	10
NL0021200063	IV	n/a	false	10	10
NL0021202933	IV	n/a	false	10	10
NL0021202785	IV	n/a	false	10	10
NL0021202826	IV	n/a	false	10	10
NL0021203273	IV	n/a	false	10	10
NL0021203219	IV	n/a	false	10	10
NL0021203098	IV	n/a	false	10	10
NL0021203273	IV	n/a	false	10	10
NL0027000000	IV	n/a	false	10	10
NL0027000074	IV	n/a	false	10	10
NL0027000381	IV	n/a	false	10	10
NL0020603521	III	n/a	false	8	8
NL0021100467	Va	n/a	true	12	12
NL0021100692	Va	n/a	true	12	12
NL0021100884	Va	n/a	true	12	12
NL0021100467	Va	n/a	true	12	12
NL0021100692	Va	n/a	true	12	12
NL0021100884	Va	n/a	true	12	12
NL0021101831	Va	n/a	true	12	12
NL0211D00000	Va	n/a	true	12	12
NL0010200499	VIc	n/a	true	17	17
NL0021100395	Va	n/a	true	12	12
NL0021100338	Va	n/a	true	12	12
NL0027001270	IV	n/a	false	10	10
NL0027001460	IV	n/a	false	10	10
NL0021100395	Va	n/a	true	12	12
NL0021100338	Va	n/a	true	12	12
NL0010200533	VIc	n/a	true	17	17

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NL0102B00000	III	n/a	true	8	8

Table A-9: Travel itinerary of transport route no. 5c from Barendrecht to Wormerveer (Zaanstad)

Transport route no. 5c from Barendrecht to Wormerveer (Zaanstad)	
Name of consignor (origin)	Food processing company
Pre-haul distance to terminal of origin (road)	6.5 km
Name of consignee (destination)	Food manufacturer
Post-haul distance from terminal of destination (road)	2.6 km
Name of terminal of origin*	ZUIDDIEPJE PONTMEYER ROTTERDAM
ISRS of terminal of origin*	NLRTM0102BZDPMR00009
Type of terminal of origin*	Terminal (not further specified)
Availability of container transshipment facilities at terminal of origin	Container crane: false Mobile harbour crane: true Reach stacker: false
Name of terminal of destination*	LODERS CROKLAAN
ISRS of terminal of destination*	NLZAD0023600LOD00087
Type of terminal of destination*	Bulk terminal
Availability of container transshipment facilities at terminal of destination	Container crane: false Mobile harbour crane: false Reach stacker: false
CEMT class (AUTOFLEX inland vessel)	II
Container layer(s)	1

*acc. to travel planner in EuRIS portal

Travelled fairway sections

Section code*	CEMT class (fairway)*	Length* [m]	Tide-dependency*	Max. speed upstream* [km/h]	Max. speed downstream* [km/h]
NL0023302526	VIb	630	false	17	17
NL0022504196	VIb	1139	false	17	17
NL0225E00309	VIa	1086	false	12	12
NL0010200499	VIc	346	true	17	17
NL0010200533	VIc	98	true	17	17
NL0010310797	VIa	7466	true	15	17
NL0010200349	VIc	1349	true	17	17
NL0010200308	VIc	409	true	17	17
NL0225E00000	VIa	3092	false	12	12
NL0010200484	VIc	148	true	17	17
NL0022502556	VIb	6610	false	17	17
NL0022500000	VIb	602	false	17	17

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NL0022500060	VIb	250	false	17	17
NL0022500095	VIb	636	false	17	17
NL0022500085	VIb	100	false	17	17
NL0010309310	VIa	9052	true	15	17
NL0010200000	VIc	3086	true	17	17
NL0102B00000	III	2387	true	8	8
NL0010310215	VIa	5822	true	15	17
NL0022502228	VIb	3279	false	17	17
NL0022500726	VIb	3306	false	17	17
NL0022500158	VIb	5679	false	17	17
NL0023302059	VIb	1420	false	17	17
NL0023302239	VIb	198	false	17	17
NL0023302221	VIb	187	false	17	17
NL0023302214	VIb	70	false	17	17
NL0023302201	VIb	125	false	17	17
NL0023302259	VIb	415	false	17	17
NL0023302319	VIb	1322	false	17	17
NL0023302301	VIb	189	false	17	17
NL0023302452	VIb	748	false	17	17
NL0023600160	Va	673	false	12	12
NL0023301615	VIb	1112	false	17	17
NL0023600108	Va	525	false	12	12
NL0023600000	Va	290	false	12	12
NL0023600029	Va	134	false	12	12
NL0023600042	Va	656	false	12	12
NL0023301727	VIb	873	false	17	17
NL0023301827	VIb	349	false	17	17
NL0023301814	VIb	134	false	17	17
NL0023600362	Va	1143	false	12	12
NL0023301875	VIb	440	false	17	17
NL0023301862	VIb	128	false	17	17
NL0023301919	VIb	1401	false	17	17
NL0023600278	Va	833	false	12	12
NL0023600227	Va	510	false	12	12
NL0022503621	VIb	1605	false	17	17
NL0022501057	VIb	2902	false	17	17
NL0022503781	VIb	4150	false	17	17

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NL0023600476	Va	1712	false	12	12
NL0010308162	VIa	11475	true	15	17
NL0022501347	VIb	8807	false	17	17
NL0023600647	Va	5108	false	12	12
NL0022503217	VIb	2896	false	17	17
NL0010308139	VIa	233	true	15	17
NL0010308081	VIa	580	true	15	17
NL0010311569	VIa	4681	true	15	17
NL0010311544	VIa	257	true	15	17
NL0022503521	VIb	532	false	17	17
NL0022503506	VIb	150	false	17	17
NL0022503574	VIb	465	false	17	17

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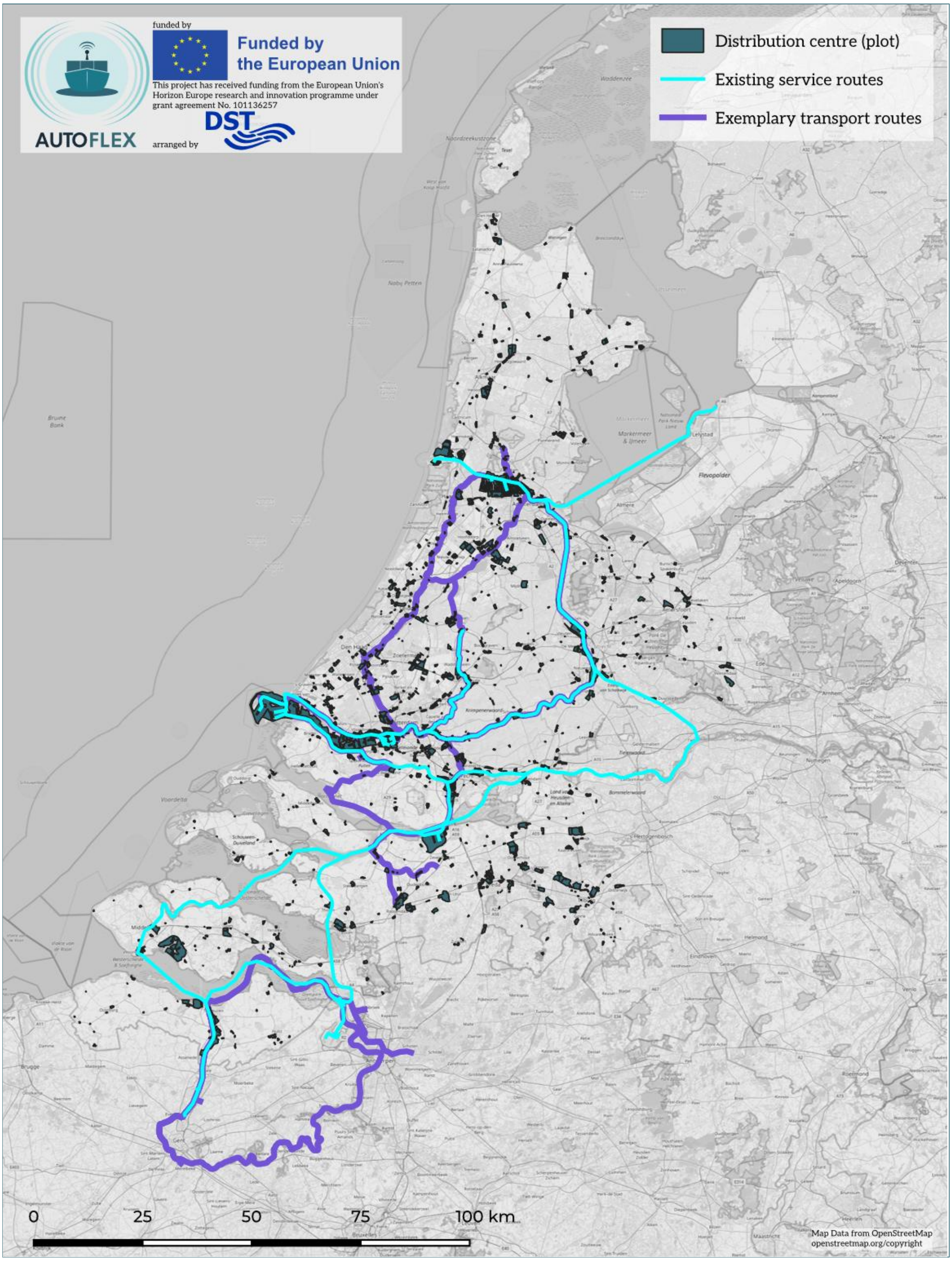

Figure A-6: Existing transport routes and exemplary transport routes in the Use Case 1 and Use Case 2 areas

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