IT Technologies for Inland Waterway Transport

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NWE574 Smart Tracking Data Network for Shipment by Inland Waterway: Deliverable No. 1.1

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NWE574 Smart Tracking Data Network for Shipment by Inland Waterway
(Smart Track 4 Waterway)

IT Technologies for Inland Waterway Transport

Deliverable No. 1.1
State-of-the-Art Report

Version: 12

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Short description

This document is the deliverable of the first activity on the WP T2. For this report project partners conducted a comprehensive review of state-of-the-art information technology (IT) used by inland waterway (IWW) operators. This review describes the different technologies existing in the IWW environment, with a focus on the questions of data standards used, such as EDI or GS1, and the level of interoperability between these existing tools.

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List of Abbreviations

AIS  Automatic Identification System
B2B  Business to Business
BSR  Baltic Sea Region
BTS  Barge Traffic System
CEF  Connecting Europe Facility
CMNI Budapest Convention on the Contract for the Carriage of Goods on Inland Waterway
CO2  Carbon Dioxide
ECDB European Commission’s Joint Research Centre about the Setup of the European Crew Database
EDCIS Electronic Chart Display and Information Systems
EFTA European Free Trade Association
EPC  Electronic Product Code
EPCIS Electronic Product Code Information Services
ERP  Enterprise Resource Planning
ETA  Estimated Time of Arrival
e tc. Et cetera “and other similar things”
EU  European Union
FMS  Fleet Management System
g  Grams
GET  Green European Transportation
GHG  Greenhouse Gas
GPS  Global Positioning System
GS1 Global Standards One
GTIN Global Trade Item Number
HF  High Frequency
ID  Identification
IaaS Infrastructure as a Service
ICT  Information and Communication Technologies
IoT  Internet of Things
IT  Information Technology
ITS  Intelligent Transport Systems
IWT  Inland Waterway Transport
IWW  Inland Waterway
L2L  Logistics Service Providers to Logistics Service Providers
LF  Low Frequency
LIM Logistics Interoperability Model
LNG  Liquified Natural Gas
LSP  Logistics Service Provider
LTE  Long-Term Evolution
NCTS  New Computerised Transit System
NGNSW Next-Generational National Single Window
NSR  North Sea Region
NtS  Notice to Skippers
NWE  North West Europe
PaaS  Platform as a Service
PCS  Port Community System
<table>
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<tr>
<td>PM</td>
<td>Particulate Matter</td>
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<td>PSA</td>
<td>Port of Singapore Authority</td>
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<td>RFID</td>
<td>Radio Frequency Identification</td>
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<td>RIS</td>
<td>River Information Services</td>
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<td>RPIS</td>
<td>RheinPorts Information System</td>
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<td>Requested Time of Arrival</td>
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<td>Software as a Service</td>
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<td>tonnes-kilometre</td>
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<td>UHF</td>
<td>Ultra-High Frequency</td>
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<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>VHF</td>
<td>Very High Frequency</td>
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<tr>
<td>VTS</td>
<td>Vessel Traffic Service</td>
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<td>VTT</td>
<td>Vessel Tracking and Tracing</td>
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<td>WMS</td>
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1. Management summary

The European commission, in its white paper “Roadmap to a Single European Transport Area – Towards a Competitive and Resource-Efficient Transport System”, aims at “optimizing the performance of multimodal logistics chains: 30% of road freight over 300 kilometres should shift to other modes such as rail or waterborne transport by 2030.”\(^1\) Inland waterways are a good alternative to road transport: carbon dioxide (CO2) emissions for 1 tonne (T) of goods transported over 1 kilometre is 93 g by road (with a high-volume truck), as compared to 26 g by waterway (with a pusher boat/barge) which is namely a reduction of 67 g CO2.

However in 2013, only 6.9% of goods were moved by waterways in EU-28, amounting to 150 billion tonnes-kilometres (tkm), of which 85% was in Germany, Benelux and France.\(^2\) The main part of these flows is high-volume freight, generally transported in bulk. According to Eurostat, palletised goods represent only 11.4% of total flows in T and 17% when expressed in tkm. This kind of freight is usually transported in small volumes, often by and for small and medium enterprises (SMEs). These pallets need to be gathered in order to be loaded into containers or directly onto vessels. Such a cargo consolidation requires logistics engineering for a precise synchronisation between actors. The Smart Track for Waterways project (ST4W), an Interreg North West Europe Project, aims to facilitate a modal shift from road to waterway for shippers in North West Europe (NEW), with a particular focus on palletised freight, thanks to a seamless synchronisation between supply chain stakeholders that enables automatic traceability data acquisition, and provides real flow visibility at any hierarchical level (pallets, containers, vessel). Thanks to a cloud-oriented and open-source approach, these tools will provide better data access to small actors, enabling them to synchronise their operations with all their partners along the supply chain, and increasing the security, effectiveness and attractiveness of IWT.

This document, “IT Technologies for Inland Waterway Transport”, is the first deliverable (No. 1.1.) of the ST4W project and depicts the highest level of general development in the scientific field of IT regarding IWT at the time the ST4W project began. This review approached the different technologies existing in the IWW environment, with a focus on data standards used and the level of interoperability between information and communication technologies.

For the compilation of the study, comprehensive desk research and the consultation of publicly accessible documents, relevant studies and publications was carried out. Primary information was collected through semi-structured expert interviews. The report is organised as follows: in the second chapter, a brief introduction of the ST4W project is presented with objectives, technological contributions, and expected benefits and impact. In the third chapter, the IWT system is described for the general reader with an explanation of the organisational frame of transport chains in IWWs. In the fourth chapter, project partners are identified, and the organisational and technological trends are analysed that could have an impact on the development of ST4W tools. Here new developments such as cloud computing, the Internet of Things (IOT) and virtual/augmented reality as well as new trends in the organisation of IWT such as synchromodality, cooperation and sustainability are discussed. Further, the theoretical knowledge is enhanced with information from 18 leaflets of ongoing and closed EU projects related to IWW navigation systems in Europe. Chapter 5 is a comprehensive overview of the highest level of the general development of IT used by IWW stakeholders for the management of: 1. freight resources, 2. terminal and port information, 3. freight and fleet tracking, 4. integrated exchange platforms. Chapter 6 includes valuable reflections from

\(^1\) European Commission (2011)
\(^2\) Eurostat
project partners about the obstacles and opportunities in the adoption of IT and communication technologies on the IWT system with significant relevance for the successful execution of the ST4W project. To inform ourselves about threats and potential factors that could influence the development of ST4W solutions in both a positive and negative way, we share lessons from past and completed projects similar to ST4W gained from project partners’ experiences. We finalise the report with conclusions about how to proceed in the project.
2. Project introduction

Background
Nowadays, transport is responsible for almost a quarter of Europe’s greenhouse gas (GHG) emissions and is the main cause of air pollution in cities. To meet the targets of long-term GHG emissions reduction set out by the European Commission, emissions need to be reduced by around two thirds by 2050. As waterway transportation is responsible for three times less CO2 than road transport, an irreversible shift to this low-emissions mobility alternative should be achieved. The NWE territory offers a unique and dense river network to exploit this opportunity.

Project objective
ST4W aims to convince shippers currently shipping palletised freight to ship road freight by water. The focus group of the project includes SMEs which ship small and highly diversified volumes. Thus, pallet flows need to be consolidated before being loaded in barges i.e. by being bundled in containers. An accurate synchronisation between chain actors and a collaborative approach are essential to ensure this consolidation and boast inland waterway transport (IWT).

Technological contribution
At present, there are no dedicated tools for waterway transportation, and for SMEs, developing their own solutions is too expensive. Consequently, ST4W aims to develop open source tools through a data exchange platform fed with hierarchical tracking data complementary to already-existing information services specially tailored to the specificities of IWT. Three pilots will be tested, validated and rolled out to user groups who do the following:

- Tracking of palletised construction materials
- Transporting dangerous goods
- Transporting containers internationally

Expected benefits and impact
A standardized data exchange with simpler and cheaper access to data that makes possible a sustainable and closer cooperation between waterway actors will make IWT more attractive for clients. The system as a whole will benefit from increased operations visibility (real-time follow-up), better workload forecast and resource allocation, with a decrease in transit time. The intended modal transfer should reduce 40,000 T of CO2 by the tenth year following the completion of the project.
3. Introduction to the IWT system

This chapter introduces IWW navigation as a transport system. This section will define the most important terms such as characteristics of this transportation mode. In IWT a diversity of stakeholders is involved on the planning, execution and controlling of transport at the national and international level. These stakeholders are the trigger for the different processes in IWT that will be depicted in this section.

System overview
According to the United Nations Economic Commission for Europe (UNECE), IWT has proven to be a “safe, multifunctional, reliable, economical and environmentally friendly mode of transport.” This explains the process involved in using IWWs for transport which includes the identification of process steps, as well as involved parties and documents.

IWT includes the transportation of cargo and passengers via IWWs, such as rivers and canals. However, this document focuses exclusively on the transportation of cargo.

In 2016, 145 billion tkm were transported via IWWs of the European Union (EU). More specifically, Germany and the Netherlands account for about 72% of the transport performance. Fifteen billion tkm of the total transport performance is allocated to container transport. More than half of the transported goods are metal ores (22.9%), coke and refined petroleum products (15.8%), and agriculture products (12.5%). With regard to the transport of dangerous goods, flammable liquids account for 75%.

Compared to the transport of goods via road, rail and pipeline, IWT has a modal share of 6%.

The following paragraph will briefly outline advantages as well as disadvantages of IWT. To start, one modern inland water vessel (length: 110 m, width: 11.45 m) can replace 150 trucks. This offers the opportunity to reduce emissions. Whereas a truck emits 104 g/tkm of GHG, an inland water vessel only emits 32 g/tkm. Also, the congested road network is relieved. In addition, IWW vessels are not subject to weekend and holiday driving bans. This means that IWT is possible 365 days per year. However, IWT is strongly affected by weather conditions. High or low tide can prevent vessels from moving which then leads to latencies and delays. Also, IWT is considered a relatively slow mode of transportation. For example, transporting goods from Duisburg to Rotterdam takes 24 hours. Finally, inland water vessels are restricted to the existing waterway network. Consequently, the transhipment into other modes of transportation is often necessary in order to reach the final destination.

Stakeholders of IWT
First, the actors involved in the transportation of goods are described. To provide the reader with a better overview of the stakeholders, these will be grouped into categories proposed by Wagenaar.

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3 UNECE (2017)  
4 Eurostat (2017)  
5 CCNR (2017)  
6 Eurostat (2017)  
7 CCNR (2017)  
8 Bundesverband der Deutschen Binnenschifffahrt e.V. (2017)  
9 Umweltbundesamt (2018)  
10 Verband für Europäische Binnenschifffahrt und Wasserstraßen e.V. (2009)  
11 Pipiora (2013)  
12 Wagenaar (1992)
### Table 1: Stakeholders of IWT\(^\text{13}\)

<table>
<thead>
<tr>
<th>Group</th>
<th>Stakeholders</th>
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<td>Shipper</td>
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<td></td>
<td>Consignee</td>
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<tr>
<td><strong>Organising group</strong></td>
<td>Forwarder</td>
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<tr>
<td><strong>Physical group</strong></td>
<td>Pre-carrier operator</td>
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<td></td>
<td>Terminal operator</td>
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<td></td>
<td>Stevedore company</td>
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<tr>
<td></td>
<td>Barge operator / Skipper</td>
</tr>
<tr>
<td><strong>Authorising group</strong></td>
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<tr>
<td></td>
<td>Port authority</td>
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**Commercial group**

The shipper or consignor is the party that originally owns the shipped goods and initiates the transportation. Depending on the form of contract, the shipper may be bearing the freight costs. The consignee is the party that receives the goods. Both the shipper and the consignee are normally not directly involved in the actual movement of goods.

**Organising group**

The forwarder and logistics service providers (LSPs) are part of the organising group. These are responsible for organising the transportation. Therefore, they act on behalf of the consignors. According to Rau, a freight forwarder “is a company that arranges your importing and exporting of goods.”\(^\text{14}\) This means that the freight forwarder employs carriers for transportation services and makes sure that all parties in the supply chain are provided with correct and complete data. However, like the commercial group, the organising group does not physically move the cargo. For this, forwarders employ members of the physical group.

**Physical group**

Members of the physical group are responsible for moving the cargo. Here, the focus is on providing an efficient, physical flow of goods.\(^\text{15}\) The pre-haulage is done by pre-carrier operators and describes the initial transportation to the inland port. For this, any mode of transportation can be used. Terminal operators are responsible for unloading the cargo from the arriving transportation mode and loading it onto the barge. However, the unloading and loading processes can also be assigned to private, so-called stevedoring companies.\(^\text{16}\) The transportation on IWWs is done by barge operators. Post-haulage moves the cargo from the arrival port to the final destination. Similar to pre-haulage, this can be done by a variety of transportation modes.

**Authorising group**

Parties of the authorising group monitor the entire process related to IWT. For this, they receive data about the cargo transportation and either approve or disapprove the arrival or departure of the

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\(^{13}\) Own illustration based on Wagenaar (2012)

\(^{14}\) Rau (2014)

\(^{15}\) Nijdam, Romochkina (2012)

\(^{16}\) Khan (2014)
Customs is responsible for making sure that the movement of cargo complies with national and international law. Inspections ensure that safety standards are met. Finally, port authorities monitor all port activities and collect statistics about cargo movements for customs and port-infrastructure-planning purposes.

IWT processes

The following figure shows the process of using IWWs for cargo transport. Although it shows the transport of containers, the transport of other types of cargo follows the same process steps, so the figure is valid for all types of cargo transport.

![Diagram of IWT processes](image)

**Figure 1: IWT as part of the physical supply chain**

As described previously, the shipper initiates the transport by employing a freight forwarder. The freight forwarder organises the logistics chain by sending instructions to a pre-carrier operator, a barge operator and an operator for post-haulage. The diagram implies that post haulage is done via truck. However, it can be done by any mode of transportation. After that, the actual physical movement of goods starts. The pre-carrier operator transports the goods to the port of departure. Here, customs procedures and inspections may take place. This depends on the type of cargo and the destination of the shipment. Terminal operators ensure that stevedores unload the arriving mode of transport and load the barge. The barge operator then moves the cargo to the port of destination or directly to the consignee, in the case where it can be reached via waterway. When post-haulage is necessary, terminal operators make sure that the barge is unloaded and that the cargo is loaded onto the operator for post-haulage. From here, the cargo is transported to the consignee.

IWT documentation

Cross-border transport is regulated by the Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway (CMNI).

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17 Van Wijngaarden (2008)
18 De Langen, Van der Horst (2008)
19 Ibid
20 Von Waldstein, Holland (2011)
The CMNI states that the shipper has to provide the forwarder with various types of information about the goods to be transported. The information should be provided before the shipping takes place and should include:

- Weight or number of goods
- Dimensions of goods
- Necessary identification marks
- Nature and characteristics of goods
- Administrative regulation (e.g. instructions for customs)
- Any additional information necessary for transport documents

In the case of dangerous or polluting goods, the shipper should clearly specify any pertinent information about the goods beforehand.

According to the CMNI, the forwarder is responsible for issuing a transport document. The transport document must be signed by the forwarder, as well as the shipmaster, who is the person navigating the vessel. In addition, the forwarder might expect the shipper to countersign the transport document. However, this signature is not legally binding.

The transport document must contain the following information:

- Name and address of the forwarder and shipper
- Name and address of the consignee
- Name or other identification of the vessel used for transportation
- Port of loading and port of discharge
- Type of goods and method of packaging
- Weight, number and dimensions of goods
- Necessary identification marks
- Transport requirements (e.g. that goods should not be carried on deck)
- Agreed provisions
- Place and date

**Bill of lading**

The bill of lading is one type of transport document and acts as proof that the shipment of cargo has taken place. Generally, the bill of lading has three main functions.

Firstly, the bill of lading provides evidence that the shipper employed a forwarder to carry out the transportation of goods. Secondly, the bill of lading documents the receipt of the cargo. In other words, the cargo is only handed over in exchange for the bill of loading. Thirdly, the bill of lading states the owner of the cargo.

The bill of lading includes the following information:

- Involved parties
- Date that goods are being loaded onto the vessel
- Port of loading and port of discharge

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21 CMNI Article 6 (2)
22 CMNI Article 7 (1)
23 CMNI Article 11 (1&2)
24 CMNI Article 11 (5)
25 CMI Article 13 (2)
26 Thompson (2018)
27 Challahan (2016)
Terms of carriage
Characteristics of the goods shipped
Transport requirements

Reporting duties
The reporting duties for IWT differ with each country and river that the vessel currently moves in. For this paper, the reporting duties in Germany are described.

Usually, port authorities require the shipmaster to report the port entrance and departure. This can be done via a variety of communication methods, such as e-mail, telephone or radio. Still, port authorities are not legally required to collect this information.28

However, if the arriving vessel is transporting dangerous or polluting goods, the shipmaster is legally required to report the port entrance to the port authorities. Here, the port authorities must collect the following information:29
- Type of vessel
- Name of vessel
- Current location
- Official ship number
- Carrying capacity
- Length and width of vessel
- Draught of vessel
- Characteristics of the goods shipped
- Number of crew members

In addition, the terminal operator is required to provide the port authorities with information regarding the following:
- Type of dangerous goods that are unloaded
- Estimated transhipping time and duration
- Place of provision of goods
- Amount of dangerous goods left on the vessel for onward transportation

Some waterways are subject to reporting duties; one example is the Schifffahrtsweg Rhein-Kleve. Reporting duties must be carried out by the following:
- Vessels that carry dangerous or polluting goods
- Tankships
- Special transports
- Cabin vessels
- Seagoing vessels
- Vessels with a length of more than 100 metres
- Convoys with a length of more than 120 metres or a width of more than 15 metres
- Vessels that carry more than 20 containers

These vessels must report their entry via radio to the Duisburg Revierzentrale. Container ships can enter the data electronically. Information that needs to be delivered generally complies with the information provided to port authorities with the addition of the transport route.30

28 AHVO §12 (1)
29 AHVO §13 (1)
30 BinSchStrO §14.15
If the vessel leaves the area covered by the Duisburg Revierzentrale, the data is submitted automatically to the neighbouring authorities. In addition, the Duisburg Revierzentrale deletes all data after the ship leaves the area.

**Customs**

The most-used customs procedure for IWT is the T1 procedure. This procedure is used for transportation within EU and European Free Trade Association (EFTA) states. Basically, the procedure ensures that borders within the EU and EFTA states can be crossed without charges until the destination country is reached. At that point, import charges are due. The T1 procedure is an external transit procedure which means that it is used for imports from non-EU countries.\(^{31}\)

In addition, the T2 procedure might be applicable for IWT. The T2 procedure is an internal transit procedure which means that the origin and destination of the goods are both located within the EU. However, the procedure ensures that no import charges are levied, in the case where non-EU or EFTA states are crossed.\(^{32}\)

Transit procedures are submitted electronically via the New Computerised Transit System (NCTS) to the customs office. The T1 and T2 procedures begin at the customs office of departure and end when the arrival of the goods is communicated to the customs office at arrival. To declare a customs procedure, a variety of information has to be entered into the NCTS. These include:

- Type of goods
- Number of items
- Number of packages
- Information about seals used
- Type of transport
- Country of destination
- Country of dispatch
- Data about the principal, consignor and consignee
- Data about the offices of departure, transit and dispatch
- Guarantee references


Upon accepting the procedure, a master reference number is issued. This number is used to identify the movement and is registered every time the cargo crosses borders.\(^{33}\) A transit accompanying document is also issued and accompanies the goods from the customs office of departure to the customs office of destination.

The NCTS is also used for communication throughout the procedure. For example, the customs office of destination must enter the arrival of cargo into the system. This ensures transparency for all parties.\(^{34}\)

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\(^{31}\) Generaldirektion Steuern und Zollunion (2016)

\(^{32}\) Generaldirektion Steuern und Zollunion (2016)

\(^{33}\) Generaldirektion Steuern und Zollunion (2016)

\(^{34}\) Generaldirektion Steuern und Zollunion (2016)
4. Organisational and technological trends

The 21st century has been shaped by the extended application and quick development of new information and communication technologies (ICT). ICT has become an integral part of people’s daily lives and a game changer in doing business. For a better understanding of these trends, they are classified in this chapter into organisational and technological trends. Below, 7 organisational trends describing the way actors in the transport and logistics field organise their operations and 7 technological trends that enable more efficient, secure and resilient production, distribution, transportation and sales are described. All these trends have an important influence on the way IWW systems of the future should operate.

4.1 Organisational trends

**Synchromodality**
A relatively new and emerging trend in the logistics sector is synchromodality (sometimes called synchronised intermodality). Synchromodality unburdens shippers by letting the LSPs make all the transport decisions, given the time and location of pick-up and drop-off.\(^{35,36,37}\) Synchromodality is a network of synchronised and well-connected modes of transport under the direction of an LSP. Together, they serve the aggregate demand for transport and are able to quickly adapt to sudden changes in the needs of customers.\(^{38}\) LSPs are able to use this synchromodal network to offer shippers a service where the shippers only have to pick times and locations for the pick-up and drop-off of the goods. The LSP then chooses how the goods will be transported to the destination. Because the synchromodal network is well-connected and harmonised, the LSP is able to assess at a glance what kind of transport mode is available.

In a model study by Zhang and Pel,\(^{39}\) synchromodality resulted in roughly the same overall costs as intermodal transport, but was able to reduce the delivery time by 8%. What is relevant for the IWW sector is that it also facilitated a considerable modal shift which reduced CO2 emissions.\(^{40}\) A LSP needs easily accessible, real-time information to make a decision about transport mode,\(^{41}\) something the IT systems of most barge operators are not yet ready for.\(^{42}\) If the IWT sector wants to benefit from synchromodality, it will have to give insight on sailing schedules, times and load factors to LSPs. This will involve further digitalisation and harmonisation with ICT systems of LSPs.\(^{43}\)

**Cooperation**
The IWT sector has always been a fragmented area; barge operators usually only own one barge or a couple of them and large fleets under one owner are very rare.\(^{44}\) This has led to a sector that could be improved by cooperation, a trend that is currently emerging.\(^{45}\) The most interesting forms of emerging cooperation are those between individual barge operators. By combining their individual barges in a large cooperative of barge operators, they can increase their market power through a

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\(^{35}\) Singh (2014)
\(^{36}\) Singh (2016a)
\(^{37}\) Struiksma (2018)
\(^{38}\) Tavasszy, Behdani, Konings (2015)
\(^{39}\) Zhang, Pel (2016)
\(^{40}\) Zhang, Pel (2016)
\(^{41}\) Struiksma (2018)
\(^{42}\) TNO (2017)
\(^{43}\) Riessen, Negenborn et al (2015)
\(^{44}\) Ecorys (2017)
\(^{45}\) Sys, Van de Voorde et al (2017)
joint negotiation with LSPs. The latter have grown so big in recent years that a negotiation between them and individual barge operators must be an uneven one. While there are currently some cooperatives, the example of Dutch dry and tanker barging, totalling four and one cooperatives, respectively, this clearly shows that cooperatives are still a rarity. That cooperation is emerging here can be shown by the merger of NPRC, one of the largest IWW cooperatives in the Netherlands, with its competitor NBC in 2016.

Other benefits of a barge operators cooperative include stable prices and long-term contracts between the barge operator and the cooperation. This gives operators more certainty about freight to transport and income generated. The sector can also profit from cooperation by giving terminal operators and LSPs one single point of contact and negotiation. Lack of the latter is tempering terminal operators’ ambitions to use more barges in hinterland transport. One group of actors has already seen an improved willingness in the sector to cooperate: fairway authorities clearly note that barge operators are more united and more willing to cooperate with new regulations.

Increasing scale and small ships
Apart from cooperation, the increasing of scale with all its benefits (economies of scale) is still a trend in the market. Before the financial crisis in 2008 a lot of new ships were coming into use, with owners usually replacing older and smaller ships with bigger ones. During and after the crisis, this specific trend decreased as cooperation is now seen as the best way to increase scale. However, there are still external factors that push the sector towards increasing scale on an individual level. Some terminals are planning to ban smaller barges during peak hours, something that will certainly impact a barge operators’ decision about the size of its barge. So although the sector has already seen a period of increasing scale on the level of individual barge operators, the trend has shifted rather than ended. However, there are factors that keep making individual increasing of scale attractive.

As older, smaller vessels were replaced by bigger ones, the sector faced problems regarding the accessibility of smaller waterways. The loss of this small IWW network made the sector less attractive compared to road transport, as the latter is almost always able to directly reach the end destination. This problem is enlarged by the fluctuation of water levels. On some stretches of the IWW network, draught is sometimes an issue. This means that ships with a deep draft have to sail with less cargo on board. Currently, some barge operators are becoming interested in small vessels again. Examples are Blue Line Logistics’ Zulu ships that are specifically designed to traverse the smaller waterways and PortLiner which has ordered 11 ships, of which 5 are in the small category. Other initiatives are Watertruck+,

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46 van Hassel, Vanelislander et al (2016)  
47 Ecorys (2017)  
48 De Binnenvaartkrant (2016)  
51 Ecorys (2017)  
53 Rabobank (2016)  
54 van Hassel (2015)  
56 Flows (2015)  
57 RTL Nieuws (2018)
Harmonisation
In line with the synchromodality and cooperation trends, the sector is taking the first steps down the road to harmonisation. Policymakers from the EU are also implementing further harmonisation of rules and regulations. Different geographical areas such as EU member states or rivers such as the Rhine or Danube have had their own set of regulations, affecting the sector with different technical requirements, validity of documents and licenses, and of course regulations regarding pollution. In recent years, however, there has been increased attention focused on harmonisation of this kind of regulations by the EU.

Harmonisation is also a trend in the way the sector uses IT systems. It is becoming increasingly important to be able to communicate with stakeholders and other modes of transport. The EU is also taking this into account, focusing on a standardisation of rules and recognising the need for the different sectors to standardise their means of communication and data sharing. The Digital Transport & Logistics Forum, for example, is thinking about new ways of accepting electronic transport documents. They are focussing on the harmonisation of data exchange standards in different modes of transport and the requirements for cloud platforms to implement these standards. It seems clear that harmonisation will play a role in the future to facilitate innovations or new business models.

The trend towards autonomous/remote-controlled shipping
The technologies to construct a remote and autonomous ship do already exist, and some of them are being used in similar projects with autonomous cars, but the IWW sector is still lagging behind. That there is a trend towards some sort of autonomous operation becomes clear when we look at some recent initiatives. A project under the EU’s Horizon 2020 programme, NOVIMAR, which started in mid-2017, is aiming to develop a vessel train. Similar to the platooning of trucks, this would entail a leading vessel, followed by digitally connected and sparsely manned follower vessels. Although not totally autonomous, this would be a first step in the direction of (semi-) autonomous or remotely controlled vessels.

Another promising initiative is PortLiner. Although it is mainly innovative because it is building barges that rely on electricity, its owners are also keeping the future in mind. Each of the 11 fully electrically powered barges is designed to be refitted as an autonomous vessel in due time. Autonomous vessels are also supported by the Dutch waterway manager Rijkswaterstaat which organised a smart shipping challenge where one of the focus areas was (semi-) autonomous shipping. (Semi-) autonomous or remote-controlled shipping is not yet in operation on the IWWs, but the sector is moving in the right direction and has been doing so for an extended period.

Sustainability
Emissions generated by the transport sector have been on the minds of the public and policymakers for a long time. This general trend is affecting the IWW sector in two different ways. The first of

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58 Erceg (2018)
59 TNO (2017)
60 AAWA (2016)
61 NOVIMAR (2017)
62 RTL Nieuws (2018)
63 Rijkswaterstaat (2017)
64 AAWA (2016)
65 Kurtenbach R, Vaupel K et al (2016)
them is that policymakers on national and European levels are envisioning a modal shift away from road transport to modes such as rail and IWWs. The European Commission is hoping to see a 30% shift away from road transport by 2030 and 50% by 2050.\textsuperscript{66} This is a huge opportunity, but it leaves the sector with big challenges on the organisational side.

The second way the sustainability trend is affecting the sector is that it is being forced to decrease its own emissions. To illustrate: between 1990 and 2000, the road and rail transport sectors were able to decrease their emissions, while the total emissions of the IWW sector remained more or less the same.\textsuperscript{67} Thus, the need to decrease emissions has become greater, with many guidelines and regulations from the EU and its member states urging the sector on towards lower and preferably zero emissions.\textsuperscript{68} To achieve this, the focus was first on a shift to more efficient forms of current fuels, such as liquefied natural gas (LNG) and biofuels.\textsuperscript{69} More recent years, however, have seen a shift of interest to fuels such as hydrogen that might decrease the sector’s emissions to zero.\textsuperscript{70}

**Labour market**

Europe’s inland waterway sector employs more than 40,000 people, most of them active in NWE countries such as the Netherlands, Belgium and Germany (CCNR, 2013). While recovering from the economic crisis, the sector has encountered shortages of qualified personnel. This problem has gotten attention from policymakers and trade associations.\textsuperscript{71}

Staff shortage is caused by a lack of awareness among students and the general public, or caused by a bad image with people focussing on long working hours and being away from home for weeks on end. Thus, the amount of people joining the sector through local education is too low to fill the current vacancies. Barge operators are solving this problem in the short term by hiring qualified staff from abroad, usually eastern Europe. Trade associations have a long-term view and are trying to make IWT more accessible for people from other sectors. The Netherlands already has a special one-year training programme where employees without nautical experience can get their IWW certificates. To make the sector more accessible for experienced people from other maritime sectors – people that are licensed to work on deep sea ships, for instance – a generic nautical education track is being envisioned.\textsuperscript{72}

Another trend is the increasing number of rules and regulation that is no longer managed by national authorities but now managed by the EU. Examples of this are the specific working time directive and the European directive on the recognition of professional qualifications, streamlining regulations and ensuring a uniform approach to professional qualifications. As another example, social partners are striving for a modernisation of manning requirements on a European level instead of a national level, and there is an ongoing EU study regarding the workload of employees in the IWT sector.

A trend that is closely related to IT developments in the sector is the digitalisation of small parts of the labour market. A good example of this is the report that is currently being written by the European Commission’s Joint Research Centre about the setup of the European Crew Database (ECDB). The report focuses on the goal to set up a digital tool for a coherent and enforceable legislative framework, specifically for the labour market. The working time directive and the directive

\textsuperscript{66} European Commission (2011)  
\textsuperscript{67} Kurtenbach R, Vaupel K et al (2016)  
\textsuperscript{68} European Commission (2011)  
\textsuperscript{69} Rabobank (2016)  
\textsuperscript{70} El Gohary, Welaya et al (2014)  
\textsuperscript{71} Ecorys (2017)  
\textsuperscript{72} Ibid
on the recognition of professional qualifications, as mentioned above, should be digitalised so that nations can enforce regulations in a simpler way. The ECDB should replace the administration of working times and workers’ qualifications and is still in development.\(^{73}\) In the longer term, integration with a similar European Hull Database and several tools are envisioned. Here, authorities, barge operators and other parties will have access to shared information.

### 4.2 Technological trends

**Cloud computing**

The term “cloud computing” refers to the provision of IT resources and on-demand services such as servers, storage, databases, network components, software, analysis options and more via the Internet. Companies that offer these computing services are referred to as cloud providers; they typically bill these cloud computing services based on their usage. Cloud computing vendors such as Amazon Web Services, Microsoft Azure and IBM Cloud operate and manage the network-connected hardware needed for these application services. The operation of cloud computing services varies slightly depending on the provider. However, in many cases, a user-friendly, browser-based dashboard is provided that simplifies resource ordering and account management for IT professionals and developers. Some cloud services can also be used with REST APIs (Representational State Transfer Application Programming Interface) and a command-line interface, allowing a developer to take advantage of various options.\(^{74}\)

Amount the benefits of cloud computing are the following:

- **Cost:** Cloud computing reduces the investment costs for hardware and software acquisition or the IT professionals for the management of infrastructure. Because cloud computing vendors can achieve greater economies of scale, cloud computing results in a lower usage-based pricing.
- **Flexible capacity:** Companies can access their needed amounts of computing resources in minutes. This gives them great flexibility and eliminates the pressure of capacity planning.
- **Productivity:** Local data centres typically involve considerable setup and administration efforts. These include a lot of time-consuming IT management tasks. Cloud computing eliminates many of these tasks, allowing the IT team to focus on more important business goals.
- **Reliability:** Cloud computing simplifies data backup, disaster recovery and business continuity by allowing data to be mirrored across multiple, redundant locations.\(^{75,76}\)

Based on a service that the cloud is offering, cloud computing can be classified as:

- **Infrastructure as a service (IaaS)** which is a type of cloud computing where users have access to IT resources such as servers, storage and network components. Companies can use their own platforms and applications in the infrastructure of the service provider. Instead of buying hardware, users pay for IaaS as needed. Companies save on the cost of purchasing and maintaining their own hardware and the infrastructure can be scaled to accommodate processing and storage requirements. Since the data is in the cloud, there is no single point of failure, and administrative tasks can be virtualised so that more time is left for other tasks.

- **Platform as a service (PaaS)** which is a type of cloud computing that provides users with a cloud environment where they can develop, manage and deploy applications. In addition to

\(^{73}\) JRC (2018)  
\(^{74}\) Microsoft (2018)  
\(^{75}\) Ibid  
\(^{76}\) Amazon (2018)
storage and other IT resources, users can use a number of pre-defined tools to develop, customise and test their applications. PaaS provides a platform with tools for testing, developing and hosting applications in the same environment. The providers are responsible for the management of security, operating systems, server software and backups, and companies can focus on development without worrying about the underlying infrastructure. Further, teams can collaborate even if they are distributed across different locations.

Software as a service (SaaS) which is a type of cloud computing where users are granted access to the software of a provider in the cloud. Users do not need to install applications on their local devices. Instead, the applications are located on a cloud network that is remotely accessible via the web or an API. The application allows users to store and analyse data and work on projects together. Users do not need to manage, install or upgrade the software because the SaaS providers are responsible for managing these tasks. The data is secure in the cloud. A device error does not lead to data loss while access to the applications is possible from almost any device with an Internet connection, virtually anywhere in the world.

Internet of Things
The Internet of Things (IoT) is the concept of connecting any object that has a power switch to the Internet with other objects that are connected to the Internet. IoT is a vast network of connected things which collect and share data about the way they are used and the environment around them. Devices and objects with integrated sensors are connected to an IoT platform that integrates data from various devices and uses analytics to share the most valuable information with applications tailored to specific requirements. These IoT platforms can determine which information is useful and which can be ignored. The information can then be used to identify patterns, make recommendations and identify potential issues before they occur. With the knowledge of advanced analytics, processes can be made more efficient. Intelligent objects and systems mean that certain tasks can be automated, especially if they are repetitive, trivial, time-consuming or even dangerous.77

Radio-frequency identification
Radio-frequency identification (RFID) refers to a technology that use radio waves to read and capture digital data encoded in a RFID tag attached to an object. It serves a similar purpose as a barcode for identifying an object. However, it can be scanned outside the line of sight via radio waves, while barcodes must be scanned with an optical scanner. Also, the RFID has the capacity to identify each individual item where the barcodes can only identify one item. Depending on the type of chip, RFID can carry various amounts of data.

A RFID system consists of two parts: a RFID tag and a RFID reader. The tag contains a microchip that stores and processes data. The reader is a two-way radio transmitter-receiver which is also called an interrogator. It emits a signal to the tag with an antenna, and the tag responds with the data stored in its microchip via radio waves. The reader will then transmit the collected results to a computer system for different use.

There are two types of RFID tags: passive RFID tags and active RFID tags. A passive RFID tag receives its power from the interrogator’s radio wave energy to relay its stored data back to the interrogator. An active RFID tag has its own embedded power supply, usually a battery, although it can also be solar-powered. This allows the tag to relay data to the interrogator on its own. It also has a longer read range than a passive RFID tag because it has the ability to emit a stronger signal. The active RFID

77 Clark (2016)
tags usually have a larger size and have a higher storage capacity than the passive RFID tags, and are more expensive. The working frequency of RFID systems can be differentiated into four categories: low frequency (LF), high frequency (HF), ultra-high frequency (UHF) and microwave RFID. Frequencies vary largely by country and region.

LF RFID systems range from 30 KHz to 500 KHz; the typical frequency is 125 KHz. LF RFID has short transmission ranges, generally from a few centimetres to less than two metres.

HF RFID systems range from 3 MHz to 30 MHz, with a typical HF frequency being 13.56 MHz. The standard range is from a few centimetres to several metres.

UHF RFID systems range from 300 MHz to 960 MHz, with the typical frequency being 433 MHz, and they can generally be read from 8-plus metres away.

Microwave RFID systems run at 2.45 GHz and can be read from more than 10 metres away.

LF and HF are generally used by passive RFID tags where UHF and microwave RFID are generally used by active RFID tags.\footnote{Rouse (2007)}

**Smartphones**
A smart mobile phone, often simply referred as a smartphone, is a mobile phone that provides considerably more extensive computer functionalities and connectivity than a conventional mobile phone. It generally has a touch screen and a digital camera, and it also includes many sensors such as a magnetometer, proximity sensor, barometer, global positioning system (GPS) sensor, gyroscope and accelerometer. A fast Internet connection is provided either via an integrated mobile broadband cellular network or via WLAN (Wireless Local Area Network).

A central feature of modern smartphones is a touch-sensitive screen with which all functions can be controlled. Based on the principle of a computer, it can run various software/applications (“apps”) thanks to operating systems specially designed for mobile phones with the Apple iOS and Google Android, and therefore in particular provide functionalities in addition to those of traditional mobile phones such as a calendar, television, calculator, web browsing capabilities, the ability to send e-mail, geolocation, voice recorder, compass and digital mapping. The most sophisticated devices benefit from voice recognition and speech synthesis; these are smartphones with integrated virtual assistants, such as Apple Siri, Google Assistant and Samsung Bixby. In principle, a smartphone can gain additional functionality over its service life via software and operating system updates.

**Telematics tracking**
The word “telematics” comes from the combination of the words telecommunications and informatics. Telematics tracking usually works with a device that uses a GPS receiver, accelerometer and input/output interface (port) to collect information such as the GPS position, speed, g-force, and data from other connected hardware or sensors. The device then sends this information through either a cellular network or satellite data service; this information is then brought into a fleet management system (FMS) for additional use.

**Vehicle tracking**
This is the use of telematics to manage and monitor vehicle operations, locations and status. The fleet manager can use the data to boost the profitability and productivity of the fleet with better
route planning, reallocate fleet units if needed, reduce downtime by determining impending vehicle maintenance events and so on.

Cargo tracking
This includes shipping containers or trailers. When telematics tracking devices are attached to them, the fleet manager can make sure they do not get lost or misused if dropped at a location, and these devices are also able to route pick-up drivers directly to the stationary cargo. It also improves customer service with real-time tracking and better-planned routes if needed.

Hands-free operation/Voice control
This is the ability to control a device by human voice. This eliminates the need to use buttons, dials and switches, so people can operate appliances easily even when their hands are full or are doing tasks such as driving a motor vehicle.

The application of voice control technology includes voice dialling, voice navigation, indoor device control, voice document retrieval and dictation data entry. The combination of voice control technology and other natural language processing technologies, such as machine translation and speech synthesis, can be used to construct more complex applications, such as voice-to-voice translation.

These areas involve include signal processing, pattern recognition, probability theory and information theory, sound mechanisms and hearing mechanisms, and artificial intelligence. Both Windows PCs and Apple Macs have built-in voice control features in their latest operating systems so that a user can control the operating system; dictate, format and save documents; start and switch between applications; send an e-mail; or fill out a form on the web. Each time it is used the system will gradually improve itself.

Mobile devices running the latest Apple iOS, Google Android, Microsoft Windows Phone or the BlackBerry OS have voice control capabilities. User may use voice control to send a text message, check the weather, set a reminder, find information, schedule meetings, send an e-mail, find a contact, set an alarm, get directions, track your stocks, set a timer and so on.

Virtual reality (VR) / augmented reality (AR)
The term “virtual reality” typically refers to computer technology that simulates the physical presence of a user in an artificial, computer-generated environment. Virtual reality creates an environment with which the user can interact and thus artificially reproduces a sensory experience which can include sight, touch, hearing and smell.

Augmented reality is the superposition of reality and elements that is artificially calculated by a computer system in real time. This includes the different methods that allow virtual objects to be realistically embedded atop an existing reality and be able to interact with it. By just pointing a mobile phone or a tablet in a certain direction or location, this can stimulate virtual elements that deliver all the relevant information needed in real time.
4.3 Ongoing and closed related projects

Rather than reviewing only academic publications, we have conducted a deep screening of related EU projects. This approach allows determining and analysing the technologies that are being currently deployed in Europe. Further, this helps us in the early stage of the project identify possible interfaces between these new products and the ones to be developed on ST4W. In this way, we can learn from experiences and knowledge gained on these projects and have useful references. We found 18 EU projects related to IWW navigation systems in Europe. Twelve of them are ongoing projects and 6 are closed ones. Although cooperation with teams of closed projects is very unlikely, their work could be very valuable for ST4W. For that reason they were included in our repository.

According to their objectives, we classified these reference projects into 5 categories:

- Greening the IWT and new barge concepts
- Traffic management for efficient operations
- Information systems for transport management
- Political framework for promoting IWT
- Modal shift promotion

Traffic management for efficient operations and information systems for transport management are relevant for ST4W, as this is where the highest potential is for knowledge exchange and interfaces with the tools to be developed on the project.

Figure 2: Systematic classification of ongoing and closed related projects

79 Own representation
## Architecture for EurOpean Logistics Information eXchange – AEOLIX

<table>
<thead>
<tr>
<th>Duration:</th>
<th>September 2016 – August 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Germany, France, Italy, Netherlands, Romania, Slovakia, Spain, Sweden, UK</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>AEOLIX aims to:</td>
</tr>
<tr>
<td></td>
<td>✤ Gain a thorough insight into the lessons learned, needs and requirements in the domain of ICT applications for logistics;</td>
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<tr>
<td></td>
<td>✤ Design an architecture for a collaborative IT infrastructure for operational connection of logistics information systems;</td>
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<td></td>
<td>✤ Implement an appropriate data access management model;</td>
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<td></td>
<td>✤ Build a common but user-tailored interface and tools to enable the IT infrastructure;</td>
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<tr>
<td></td>
<td>✤ Test, validate and implement the AEOLIX prototype in 11 living labs of logistics business communities across Europe;</td>
</tr>
<tr>
<td></td>
<td>✤ Monitor the impacts of AEOLIX based on environmental, economic and social impacts; and</td>
</tr>
<tr>
<td></td>
<td>✤ Develop an exploitation business model to enable roll-out and deployment of the concept across Europe, and possibly the rest of the world.</td>
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<tr>
<td>Developing Solution:</td>
<td>AEOLIX will develop a solution for connecting logistics information systems of different characteristics, intra- and cross-company, for the immediate (real-time) exchange of information in support of logistics-related decisions. The ambition is to develop architecture for a distributed open system for the exchange of information among key logistics actors (commercial companies as well as relevant authorities), enabling increased use and impact of such information in the value chain.</td>
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<td>Web Page:</td>
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<tr>
<td>Relevance for ST4W:</td>
<td>High</td>
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<tr>
<td>Possibility for Interfaces:</td>
<td>Knowledge exchange, IT tools interfaces</td>
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Clean Inland Shipping – CLINSH

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<td>Partner Countries:</td>
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<td>Project’s Targets:</td>
<td>CLINSH aims to:</td>
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<tr>
<td></td>
<td>✦ Demonstrate the effectiveness of greening measures in the inland waterway sector;</td>
</tr>
<tr>
<td></td>
<td>✦ Stimulate the sector to apply these greening measures;</td>
</tr>
<tr>
<td></td>
<td>✦ Contribute to improving air quality;</td>
</tr>
<tr>
<td></td>
<td>✦ Achieve a total emissions reduction of 6,000 T (comparable to the yearly NOx emissions of Malta) over the total depreciation time of the vessel/engine (on average 20 years), with vessels maintaining the technology after the project.</td>
</tr>
<tr>
<td>Developing Solution:</td>
<td>Within CLINSH 30 ships are being selected. The ships will be equipped and the performance of various emissions reduction techniques and alternative fuels will be tested. The measurement results are collected in a database. The results provide a tool for local, regional, national and European governments for (new) policies on the greening of waterways. The results also provide skippers more information about the most cost-effective environmental measures for their ship. In addition, CLINSH will highlight the benefits of shore power for local governments. Until now the energy needed for heating, lighting and other activities on board has mostly come from generators. A switch to shore power will help reduce ships’ emissions and improve the air quality around ports. Expected results of the project are:</td>
</tr>
<tr>
<td></td>
<td>✦ Thirty ships provided with various NOx and particulate matter (PM) reduction techniques and monitored for NOx, PM and all other necessary parameters (plus 15 already equipped with selective catalytic reduction for NOx monitoring, which initial results suggest reduce emissions by 70-80%);</td>
</tr>
<tr>
<td></td>
<td>✦ Emissions reductions in the demonstration actions of 288 NOx and 7.2 PM T per year;</td>
</tr>
<tr>
<td></td>
<td>✦ An onshore power supply demonstration that is expected to reduce emissions in port areas;</td>
</tr>
<tr>
<td></td>
<td>✦ An emissions inventory database, including all relevant ship information under real-world conditions;</td>
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<tr>
<td></td>
<td>✦ Scenarios that show the expected impact on emissions depending on policy changes and/or incentives;</td>
</tr>
<tr>
<td></td>
<td>✦ Air pollution concentration maps for various scenarios based on high-resolution modelling;</td>
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<td></td>
<td>✦ A monitoring protocol leading to a clean shipping index for financial incentives;</td>
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<tr>
<td></td>
<td>✦ A decision-making tool, enabling ship owners to make a first selection of feasible greening methods and their costs; and</td>
</tr>
<tr>
<td></td>
<td>✦ Policy tools and recommendations based on scenarios.</td>
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<tr>
<td>Web Page:</td>
<td><a href="https://www.clinsh.eu/">https://www.clinsh.eu/</a></td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>Low</td>
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<tr>
<td>Possibility for Interfaces:</td>
<td>Building up user groups</td>
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## Consistently Optimised Resilient Secure Global Supply Chains – CORE

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</tbody>
</table>
| Project’s Targets: | CORE will consolidate, amplify, extend and demonstrate EU knowledge and capabilities and international co-operation for securing supply chains while maintaining or improving business performance, with specific reference to key supply chain corridors. CORE will be driven by the requirements of: 
  ✤ The customs, law enforcement authorities, and other agencies nationally and internationally to increase effectiveness of security and trade compliance, without increasing the transaction costs for business and to increase co-operative security risk management (supervision and control); 
  ✤ The business communities, specifically shippers, forwarders, terminal operators, carriers and financial stakeholders to integrate compliance and trade facilitation concepts such as green lanes and pre-clearance with supply chain visibility and optimisation. |
| Developing Solution: | CORE will consolidate solutions developed in reference projects in each supply chain sector (port, container, air, post). Implementation-driven R&D will be then undertaken and designed to discover gaps and practical problems and to develop capabilities and solutions that could deliver sizable and sustainable progress in supply chain security across all EU member states and on a global scale. |
| Web Page:      | http://www.coreproject.eu/   |
| Relevance for ST4W: | Moderate |
| Possibility for Interfaces: | Knowledge exchange |
Enhancing freight Mobility and logistics in the BSR by strengthening IWW and river sea transport and proMoting – EMMA

Duration: March 2016 – February 2019
Partner Countries: Finland, Germany, Lithuania, Poland, Sweden

Project’s Targets: The EMMA project aims at tackling the challenges and opportunities focused on inland- and river-sea shipping, especially those that include increasing the modal share of inland- and river-sea shipping to, from and between Baltic Sea Region (BSR) countries, fostering a better integration of inland- and river-sea shipping in the BSR transport chains and the EU Strategy for the BSR. The main goals are as follows:

- Improving competitiveness and strengthening the future development of IWT in the BSR;
- Identifying possible new IWT services;
- Raising the awareness of the potentials of IWT in the BSR;
- Reducing bureaucratic and regulatory barriers hindering IWT development in the BSR and ensuring the better standing of IWT in policy and society;
- Proving the feasibility of IWT in the BSR with 5 pilot activities.

BSR policies will be addressed, aiming at higher political (and financial) support for IWT. The project will contribute to changing the mind-set of transport-related politics and politicians in the BSR and Europe through pilot demonstrations and lobby work.

Developing Solution: To initiate a long-term strategy, pilots will be used to showcase and demonstrate the potential of IWT and open up new market segments. For these pilots business plans and organisational frameworks will be prepared to prove that IWT can be a reliable and efficient transport solution also in international transport chains within the BSR.

These pilots include:

- Running a competitive improvement plan for IWT in the BSR
- Reducing bureaucratic and regulatory barriers hindering IWT development in the BSR
- Raising the awareness of the potentials of IWT in the BSR
- Giving IWT a stronger voice and better standing in policy and society

Web Page: http://project-emma.eu/

Relevance for ST4W: Moderate
Possibility for Interfaces: Knowledge exchange, joint workshops
Göta älv River Information Services – GOTRIS

<table>
<thead>
<tr>
<th>Duration:</th>
<th>August 2012 – December 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Sweden</td>
</tr>
</tbody>
</table>

**Project’s Targets:**
The vision of GOTRIS was to develop a platform to solve various actors’ needs and to demonstrate traffic management between different modes of transport. By bringing together all actors and letting the railroad, the shipping and the road traffic share information and services in a river information service (RIS) for the river Göta älv it is intended to do the following:

- Provide opportunities for increased freight train traffic across the river;
- Create social benefits by reducing interference in the conflict between opposing national interests;
- Coordinate freight traffic over the river to and from the port of Gothenburg with the traffic on the river requiring the bridge to open;
- Coordinate information about bridge openings with road and tram traffic in Gothenburg;
- Provide for a developed inland and regional growth in Värmland and Västra Götaland;
- Provide opportunities for green growth and the transfer of freight volumes from road to sea;

A fully developed GOTRIS platform was designed to create well-functioning freight traffic over the river that facilitates expansion of the port of Gothenburg, while the traffic on the river Göta älv is optimised and has the possibility to expand. From a social perspective, efficient and environmentally friendly transport can be achieved by minimizing waiting time and ship bunker use. From the perspective of the city, a well-functioning and attractive city with minimal interference from bridge openings could be achieved.

During a pilot study, which was conducted between autumn 2010 and spring 2011, a number of key areas where intelligent transport systems (ITS) solutions could eliminate or reduce barriers for a shuttle service on the river were identified. ITS could also provide improved opportunities for shuttle service on the river and constitute legal or operational conditions for a shuttle service on the river. In autumn 2011 and spring 2012 a project was conducted within the Vinnova program called “Challenge-Driven Innovation” which formed the basis for this project.

**Developing Solution:**
GOTRIS platform, built up from a set of well-defined subsystems, each of which has a specific task:
- GOTRIS hub
- The Voyage module
- The AIS module
- The Train module
- The Prognosis module
- The FrontEnd

**Web Page:**
http://gotris.se/

**Relevance for ST4W:**
Moderate

**Possibility for Interfaces:**
Architecture of the platform
### Pilot implementation of an Upper Rhine traffic management platform – Rhine-Alpine

<table>
<thead>
<tr>
<th>Duration:</th>
<th>July 2014 – June 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>France, Germany, Switzerland</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>The action, involving two member states and a neighbouring country, is aimed at:</td>
</tr>
<tr>
<td></td>
<td>✦ Implementing an innovative ICT traffic management platform for IWT to improve the overall logistics processes on the upper Rhine;</td>
</tr>
<tr>
<td></td>
<td>✦ Enhancing modal shift with road and railway transport, leading to higher efficiency in the IWW logistics processes as well as to lower CO2 emissions by a reduction of waiting times for ships and better capacity utilisation.</td>
</tr>
</tbody>
</table>

In order to reach the targets, an IT platform was developed. The pilot version was initially introduced at the 3 port locations of RheinPorts (Basel-Mulhouse-Weil am Rhein) with a total of 7 container terminals.

The so-called RheinPorts Information System (RPIS) has been accessible to all parties involved in the process since May 2015 (in particular for IWW companies and terminal operators). As part of a second project activity, a feasibility study was carried out to introduce the system at 6 other locations on the Upper Rhine (Colmar/Neuf-Brisach, Strasbourg, Kehl, Karlsruhe, Mannheim and Ludwigshafen) with local adjustments. Furthermore, as part of the project, the functional extension of the system and also geographical extensions beyond the Upper Rhine were examined.

Coordinator: RheinPorts Bâle-Mulhouse-Weil am Rhein

<table>
<thead>
<tr>
<th>Developed Solution:</th>
<th>The action included the following pilot deployment in inland ports:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✦ An ICT traffic management platform at 3 ports in France, Germany and Switzerland;</td>
</tr>
<tr>
<td></td>
<td>✦ A feasibility study for the roll-out of the ICT traffic management platform at 6 other ports along the Upper Rhine and;</td>
</tr>
<tr>
<td></td>
<td>✦ The conceptual design for the functional and geographical extension of the platform to non-containerised cargo, rail and truck hinterland traffic.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Web Page:</th>
<th><a href="http://www.upper-rhine-ports.eu/de/component/content/article/9-page-de-contenu-simple/180-das-vorhaben-oberrhein-verkehrsmanagement-plattform.html">http://www.upper-rhine-ports.eu/de/component/content/article/9-page-de-contenu-simple/180-das-vorhaben-oberrhein-verkehrsmanagement-plattform.html</a> (in German or French only)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><a href="https://ec.europa.eu/inea/sites/inea/files/2014-eu-tm-0210-s.pdf">https://ec.europa.eu/inea/sites/inea/files/2014-eu-tm-0210-s.pdf</a> (in English)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relevance for ST4W:</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possibility for Interfaces:</td>
<td>Knowledge exchange, IT tools interfaces</td>
</tr>
</tbody>
</table>
# RIS-enabled Corridor Management Execution – RIS COMEX

<table>
<thead>
<tr>
<th>Duration:</th>
<th>February 2016 – December 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Hungary, Luxembourg, Netherlands, Romania, Serbia, Slovakia</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>The RIS COMEX project aims for implementation and operation of cross-border RIS based on the operational exchange of RIS data. These RIS-based corridor (information) services will lead to improved traffic management by the authorities and transport management by the logistics sector.</td>
</tr>
</tbody>
</table>

**The main objectives of RIS COMEX are:**

- Development of an overall corridor RIS management concept (starting from CoRISMa results) in dialogues between RIS providers and logistics users (e.g. shippers, skippers, and terminal operators) to ensure the relevance of the implemented services;
- Implementation and permanent operation of selected parts of the overall concept, providing increased quality and availability of fairway, traffic and transport information services, resulting in a considerable increase in efficiency within inland navigation transports and also directly contributing to the utilisation of the general benefits provided by RIS, e.g. increase of safety, efficiency and environmental friendliness of inland navigation as a transport mode.
- Definition of an agreement on operational arrangements (legal, organisational, financial, technical, quality) to ensure sustainable further development, implementation and operation of infrastructure and services for harmonised RIS-enabled corridor management beyond the lifetime of the project.
- Harmonisation of data exchange concepts for RIS data through the cooperative development and specification of RIS-enabled corridor services to avoid the rise of different data exchange concepts.
- Progress on harmonisation of transport information services on the European- and/or corridor-level based on existing solutions and concepts (e.g. IVS90, imagine, ERI agent, R2D2).
- RIS COMEX, as the platform bringing together public and private actors in RIS-enabled corridor management, which will facilitate the dialogue between providers of RIS and logistics users (e.g. shippers, vessel and fleet operators, terminal operators).

<table>
<thead>
<tr>
<th>Developed Solution:</th>
<th>Corridor RIS management concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Defined and agreed-on operational arrangements (legal, organisational, financial, technical, quality) for harmonised RIS-enabled corridor management</td>
</tr>
<tr>
<td></td>
<td>RIS-enabled Corridor Services</td>
</tr>
<tr>
<td>Web Page:</td>
<td><a href="https://www.riscomex.eu/">https://www.riscomex.eu/</a></td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>High</td>
</tr>
<tr>
<td>Possibility for Interfaces:</td>
<td>Knowledge exchange, IT tools interfaces, joint workshops</td>
</tr>
</tbody>
</table>
Non-Carbon River Boat Powered by Combustion Engines – RIVER

<table>
<thead>
<tr>
<th>Duration:</th>
<th>September 2017 – June 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>France, Germany, Luxembourg, Netherlands, UK</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>The EU recently adopted rules requiring limits on carbon emissions and requiring type-approval of internal combustion engines for non-road mobile machinery (Directive 97/68/EC, 01/2017). This set more stringent limits for emissions from IWW vessels. There is an urgent need for emissions reduction due to stronger environmental standards aims. Replacing NWE’s ageing fleet with RIVER technology offers the potential for emissions reduction. The objective of RIVER is to reduce or eliminate the pollutants from the polluting engines. It is expected that 6,600 engines on existing vessels will need to be replaced in 2018-50 and 2,400 new vessels will come into operation. RIVER aims to address these issues and to apply an oxy-fuel combustion technology for diesel engines that eliminates NOx (part of the GHG), and to capture and store all CO2 emissions and reduce fuel consumption by up to 15%. The project partners will use the research on engine control from the Interreg 2 Seas project SCODECE and results on IWT from the PROMINENT EU project to support their work in RIVER. This technology will then be tested, demonstrated and integrated into an existing vessel operating in the UK. A small-scale lab transforming CO2 into a bio-solvent will be implemented, and a feasibility study for a large vessel will be carried out during the project. At the end of the project, the NOx emissions of the equipped vessel will be reduced by 194 kg; 24 T/year CO2 will be avoided and the consumption reduced by 1,500 litres/year. After 10 years, a European campaign through the network linked to this technology involving IWW operators, national authorities and engine manufacturers will ensure that hundreds of boat retrofits will be achieved. The retrofit of 300 medium-sized boats is expected, resulting in the reduction of 21,000 T/year of CO2.</td>
</tr>
<tr>
<td>Developing Solution:</td>
<td>✫ Oxy-fuel combustion technology for diesel engines ✫ CO2 emissions capture ✫ Fuel consumption reduction</td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>Moderate</td>
</tr>
<tr>
<td>Possibility for Interfaces:</td>
<td>RIVER technology could be associated with one of the pilots</td>
</tr>
</tbody>
</table>
## Efficient and clean vessels, monitoring emissions performance and qualification of professionals – PROMINENT

### Duration:
May 2015 – April 2018

### Partner Countries:
Austria, Belgium, Germany, Netherlands, Romania,

### Project’s Targets:
Address the key needs for technological development, as well as the barriers to innovation and greening in the European inland navigation sector by focusing on:

- Massive transition towards efficient and clean vessels by developing cost-effective solutions applicable to 70% of the EU fleet and the reduction of the corresponding implementation costs by 30%
- Certification and monitoring of emissions performance and development of innovative regimes
- More standardised solutions, designs, models and provisions of cost-efficient concepts for emissions reduction
- Harmonisation and modernisation of professional qualifications and the stimulation of the further integration of IWT into sustainable transport chains

### Developed Solution:
Advanced concepts for emissions reduction:

- Development of an efficient navigation advice tool as a support tool for reducing the fuel consumption of an inland vessel and achieving emissions reduction
- Assessment of two concepts which can directly result in achieving the new NRMM Stage V limits for PM and NOx: after-treatment and LNG in IWW vessels
- Demonstration of performance of standardised retrofit diesel after-treatment systems
- Certification system for monitoring and evaluation of the emissions behaviour of corresponding solutions
- Assessment of alternative Stage V certification options, including a “Stage V”-type approval method for retrofit after-treatment systems as well as permanent on-board monitoring.
- Digital and simulation-based tools for vocational training in inland navigation.
- Logistics education, comprising usage of simulations, demonstration of a European electronic service record book and an electronic logbook, as well as demonstration of a pilot community of practice in logistics education.

Roadmaps/Roll-out strategies consisting of identified barriers and recommended follow-up actions for the PROMINENT areas:

- Certification, monitoring and enforcement of emissions limits
- Engine room improvements
- Skilled workforce and quality jobs
- Energy efficient navigation

### Web Page:
[www.prominent-iwt.eu](http://www.prominent-iwt.eu)

### Relevance for ST4W:
Moderate

### Possibility for Interfaces:
Knowledge exchange
**Shared European Logistics Information Space – SELIS**

<table>
<thead>
<tr>
<th>Duration:</th>
<th>September 2016 – August 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Belgium, Cyprus, France, Germany, Greece, Italy, Netherlands, Portugal, Spain, UK</td>
</tr>
</tbody>
</table>
| Project’s Targets:   | SELIS aims at delivering a platform for pan-European logistics applications by:  
  - Embracing a wide spectrum of logistics perspectives and creating a unifying operational and strategic business innovation agenda for pan-European green logistics  
  - Establishing a research and innovation environment using living labs to provide data that can be used for discovery of new insights that will enable continuous value creation supporting the large-scale adoption of SELIS |
| Developed Solution:  | The Shared European Logistics Intelligent Information Space is a network of logistics communities’ specific, shared intelligent information spaces termed SELIS community nodes. SELIS community nodes link with their participants’ existing systems through a secure infrastructure and provide shared information and tools for data acquisition and use, according to a cooperation agreement. Connected nodes provide a distributed common communication and navigation platform for pan-European logistics applications. The members of each node decides what information wishes to publish and what information wants to subscribe to. |
| Web Page:            | www.selisproject.eu |
| Relevance for ST4W:  | High |
| Possibility for Interfaces: | Knowledge exchanges, joint workshops |
**Watertruck+**

<table>
<thead>
<tr>
<th>Duration:</th>
<th>2014 – 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Belgium, Netherlands</td>
</tr>
<tr>
<td><strong>Project’s Targets:</strong></td>
<td>Watertruck+ is a European project that aims at the gradual introduction of an innovative concept for the transport of goods on small waterways (CEMT I-IV) that can unlock the economic potential of a region through the use of small, self-propelled or un-propelled, standardised barges. Combined with large or small environmentally friendly push boats, used for pushing the convoys, the concept ensures maximum flexibility of operations while maintaining maximum regional coverage by connecting small IWWs with the Trans-European Transport Networks (TEN-T). The Watertruck+ project aims to achieve a solution that is complementary to the existing IWW activities and that is an answer to the ever-diminishing fleet.</td>
</tr>
<tr>
<td>Developing Solution:</td>
<td>The project’s actions are focused on the development and testing of transport units (barges and push boats) that sail in convoys and that can be coupled and decoupled in a fast and flexible way.</td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>Low</td>
</tr>
<tr>
<td>Possibility for Interfaces:</td>
<td>Watertruck+ focuses on freight flows that are currently transported by road and on new flows, thereby increasing the market share of IWWs in the European modal split</td>
</tr>
</tbody>
</table>
**IWT Solutions – #IWTS2.0**

<table>
<thead>
<tr>
<th>Duration:</th>
<th>August 2017 – June 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Belgium, Germany, Netherlands, Sweden, UK</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>#IWTS 2.0 is a project co-funded by the North Sea Region (NSR) Programme 2014-2020. #IWTS2.0 targets are:</td>
</tr>
<tr>
<td></td>
<td>✦ Realizing a quick modal shift by introducing new and proven logistics technologies and support logistics managers that decide about modal shifts</td>
</tr>
<tr>
<td></td>
<td>✦ Making better use of existing waterways by adapting them towards sufficient standard-sized vessels</td>
</tr>
<tr>
<td></td>
<td>✦ Making better use of existing waterways by developing innovative sustainable small barge concepts</td>
</tr>
<tr>
<td></td>
<td>✦ Modernizing IWT education; training with a focus on navigation on smaller waterways</td>
</tr>
<tr>
<td></td>
<td>✦ Facilitating the use of IWT on smaller waterways (comprehensive network) in the NSR linking them to main TEN-T corridors</td>
</tr>
<tr>
<td>Developing Solution:</td>
<td>By piloting 8 small waterway modal shifts, the project will showcase proven concepts for coastal and inland shipping that e.g. look beyond concurrent limitations of existing business models, legislation, goods flow characteristics and vessel concepts and can be adopted by the market, including innovative barge, waterway, transhipment, (un)loading, freight flow mapping, and modal shift decision-making solutions.</td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>Low</td>
</tr>
<tr>
<td>Possibility for Interfaces:</td>
<td>Knowledge exchange, joint workshops</td>
</tr>
</tbody>
</table>
## Connecting Citizen Ports 21 – CCP 21

<table>
<thead>
<tr>
<th>Duration:</th>
<th>September 2009 – December 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>France, Belgium, Germany, Netherlands, Switzerland</td>
</tr>
<tr>
<td><strong>Project’s Targets:</strong></td>
<td>Connecting Citizen Ports 21 (CCP21) brings together 7 major inland ports to promote connectivity and sustainable transport by optimising the organisation of freight logistics and sustainable spatial development of inland ports. Inland ports are the nodes in the transport chain where freight and passengers are being transferred and economic added value is realised. Strengthening and enlarging the capacity of the node will enlarge the efficient use of the existing network.</td>
</tr>
<tr>
<td><strong>Developing Solution:</strong></td>
<td>CCP21 partners have been collaborating to achieve results in the context of each objective. Through various studies, tools, infrastructure works and communication activities, the project has increased the awareness and acceptability of inland ports, promoted cohabitation through innovative and multipurpose land use, improved the organisation of freight logistics and promoted sustainable city distribution. The project results include:</td>
</tr>
<tr>
<td></td>
<td>✦ An ICT tool that improves the level of cooperation between different inland ports</td>
</tr>
<tr>
<td></td>
<td>✦ An awareness and acceptability strategy that increases the image of inland ports in a positive way</td>
</tr>
<tr>
<td></td>
<td>✦ A visualisation tool that shows the benefits of IWT in an attractive way to the general public</td>
</tr>
<tr>
<td></td>
<td>✦ Infrastructures that combine port activities with (semi-)public spaces which legitimises port activities in urban areas and city centres, improves the economic performance within and for the city, improves connectivity, and contributes to the modal shift</td>
</tr>
<tr>
<td></td>
<td>✦ The construction of a multimodal urban logistics platform that helps reduce the burden of economic, commercial and transport activities on the environment</td>
</tr>
<tr>
<td></td>
<td>✦ The construction of a multipurpose vessel for city distribution that contributes to the modal shift</td>
</tr>
<tr>
<td></td>
<td>✦ A transferable toolbox that aims to disseminate the lessons learned during the CCP21 project, with all methodologies, duplicable reports, best practices, case studies, etc. and that reflects the experiences of all partners</td>
</tr>
<tr>
<td></td>
<td>✦ A position paper based on a long-term vision for inland ports</td>
</tr>
<tr>
<td></td>
<td>✦ Audio-visual material showing each partner’s project</td>
</tr>
<tr>
<td><strong>Web Page:</strong></td>
<td><a href="http://www.citizenports.eu/">http://www.citizenports.eu/</a></td>
</tr>
<tr>
<td><strong>Relevance for ST4W:</strong></td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Possibility for Interfaces:</strong></td>
<td>Knowledge exchange</td>
</tr>
</tbody>
</table>
Efficient Carbon-reduction and Optimisation of Logistics Operations Generated via Innovative Services, Training and ICT using Cooperative Standards – ECOLOGISTICS

<table>
<thead>
<tr>
<th>Duration:</th>
<th>January 2011 – June 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Belgium, France, Germany, Luxembourg, Netherlands, UK</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>Ecologistics aims at raising awareness and opportunities for companies to optimise their freight operations by using standardised, collaborative ICT tools.</td>
</tr>
</tbody>
</table>

The tools developed by Ecologistics will enable an improved data exchange between the actors from different levels of the supply chain. Currently, large companies and SMEs are not operating on the same information level: SMEs have little time and no internal resources to match their current organisation to an international and standardised transport flow. Ecologistics will provide solutions to fill the information gap between large companies and SMEs by promoting a collaborative information network based on a European standard called the Electronic Product Code (EPC) Network which enables direct connections between people and travelling objects (concept IoT).

Ecologistics will tackle the supply chain synchronisation challenge by providing a unified and normalised ICT tool to supply chain managers. The highest efficiency can only be reached if all actors participate in common efforts based on international standards. By enabling this ICT tool through the entire supply chain, more efficient, more communicative and greener NWE transportation will be triggered.

Implementing such innovative ICT solutions will enable the reduction of freight congestion, waiting times in delivery places, unnecessary trips and traceability issues and thus lead to a greener and more efficient transportation that positively impacts the NWE economy (winning logistics business and increasing companies’ competition and growth) and the NWE environment (green logistics, decrease of carbon footprint).

| Developing Solution: | This ICT-based demonstrator will be based on a European standard called the EPC-Network, allowing direct connection between people and travelling objects (concept of IoT). This EPC-Network demonstrator will be implemented on 3 interactive levels:  
Objects identification level: A complete range of automatic data collection tools (1D and 2D barcodes, electronic tags and beacons) allowing communication with the physical world (items, parcels, pallets)  
Local data capture level: A software platform in order to process and store this data  
Transnational data exchange level: a network of Electronic Product Code Information Service (EPCIS) gateways, allowing wide traceability data exchange and interoperability between various business areas, thanks to EPC-Network standards. |
| Web Page: | http://www.ecologistics-project.eu/ |
| Relevance for ST4W: | High |
| Possibility for Interfaces: | Knowledge exchange, joint workshops |
### European e-freight capabilities for co-modal transport – e-Freight

<table>
<thead>
<tr>
<th>Duration:</th>
<th>January 2010 – June 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Austria, Cyprus, Finland, Germany, Greece, Hungary, Ireland, Latvia, Netherlands, Norway, Portugal, Spain, Sweden, UK</td>
</tr>
<tr>
<td>Project’s Targets:</td>
<td>The key issues addressed in e-Freight are:</td>
</tr>
<tr>
<td></td>
<td>✗ Simplification and harmonisation of regulatory requirements and accelerated development of EU and national single windows to streamline traffic and cargo reporting to authorities particularly in the context of co-modal transport. Further, safety and security issues need special attention, particularly in establishing efficient collaboration between authorities and transportation stakeholders to improve the development of capabilities for proactive and remedial measures to protect the environment as well as the security of freight transport networks.</td>
</tr>
<tr>
<td></td>
<td>✗ Improved ways for transport stakeholders to establish co-operation and to integrate their processes. For this, the e-Freight project will introduce information highways for co-modality in order to denote solutions assisting transport operators to establish common end-to-end transportation processes incorporating regulations compliance and “intelligent” monitoring and control.</td>
</tr>
<tr>
<td></td>
<td>✗ Increase of stakeholder engagement in the promotion of open networks and the innovative but practical utilisation of web services’ standards and enabling technologies, including a suitable registry of e-Freight services.</td>
</tr>
<tr>
<td>Developing Solution:</td>
<td>The e-Freight project aimed to develop the following generic e-Freight solutions:</td>
</tr>
<tr>
<td></td>
<td>✗ Next-Generation National Single Windows (NGNSW) that allow all parties involved in trade and transport to lodge information and documents on a single entry point.</td>
</tr>
<tr>
<td></td>
<td>✗ Central EU national single windows’ Support Services, a central EU-level module to facilitate information exchange among NGNSW</td>
</tr>
<tr>
<td></td>
<td>✗ Collaborative security risk management that supports real-time tracking with exchange of security risk information</td>
</tr>
<tr>
<td></td>
<td>✗ The setup of co-modal transport networks addressing co-operation strategies to improve the footprint of the entire supply chain</td>
</tr>
<tr>
<td></td>
<td>✗ Co-modal shipment planning to assist clients in specifying, comparing and negotiating co-modal services</td>
</tr>
<tr>
<td></td>
<td>✗ The monitoring of transport services execution to detect deviations from the agreed-on transport plan</td>
</tr>
<tr>
<td></td>
<td>✗ A single transport document application which generates electronic transparent documents from existing operational data</td>
</tr>
<tr>
<td>Relevance for ST4W:</td>
<td>High</td>
</tr>
<tr>
<td>Possibility for Interfaces:</td>
<td>Knowledge exchange</td>
</tr>
</tbody>
</table>
## Service Platform for Green European Transportation – GET Service

<table>
<thead>
<tr>
<th>Duration:</th>
<th>October 2012 – September 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>Netherlands, Austria, Switzerland, Germany, Greece</td>
</tr>
<tr>
<td><strong>Project’s Targets:</strong></td>
<td>Currently, basic systems for transportation and route planning exist. The Green European Transportation (GET) Service platform brings these systems to the next major level by:</td>
</tr>
<tr>
<td></td>
<td>✤ Enabling improved transportation and route planning, by incorporating transportation- and logistics-related tasks, such as transfer of goods and administrative tasks, into the planning</td>
</tr>
<tr>
<td></td>
<td>✤ Facilitating more accurate transportation and route planning, by using real-time information from multiple information sources</td>
</tr>
<tr>
<td></td>
<td>✤ Facilitating quick changes to transportation plans, including the execution of necessary transportation-related tasks, such as (de-) reservation of necessary resources and unloading of already-loaded goods;</td>
</tr>
<tr>
<td></td>
<td>✤ Enabling holistic planning, where transportation routes and placement of transportation resources is planned jointly to optimise resource usage.</td>
</tr>
<tr>
<td></td>
<td>A prototype of the GET Service platform will be implemented, along with a collection of information provisioning services and end-user services for transportation planners and drivers of transportation vehicles. With this prototype the platform’s practical applicability to reduce CO2 emissions will be validated by solving usage scenarios related to co-modality, synchronomodality and resource distribution.</td>
</tr>
<tr>
<td><strong>Developed Solution:</strong></td>
<td>The GET Service platform with subsystems for information aggregation, real-time planning, transportation control and transportation service development. The GET Service Platform provides transportation planners and drivers of transportation vehicles with the means to plan, re-plan and control transportation routes efficiently and in a manner that reduces CO2 emission.</td>
</tr>
<tr>
<td></td>
<td>The GET Service platform contributes to the state of the art by providing:</td>
</tr>
<tr>
<td></td>
<td>✤ Novel real-time transportation planning algorithms</td>
</tr>
<tr>
<td></td>
<td>✤ A transportation-specific service development subsystem, transportation control and reconfiguration mechanisms</td>
</tr>
<tr>
<td></td>
<td>✤ Automated real-time information aggregation mechanisms</td>
</tr>
<tr>
<td><strong>Web Page:</strong></td>
<td><a href="http://getservice-project.eu/">http://getservice-project.eu/</a></td>
</tr>
<tr>
<td></td>
<td><a href="https://cordis.europa.eu/project/rcn/105698_en.html">https://cordis.europa.eu/project/rcn/105698_en.html</a></td>
</tr>
<tr>
<td><strong>Relevance for ST4W:</strong></td>
<td>High</td>
</tr>
<tr>
<td><strong>Possibility for Interfaces:</strong></td>
<td>Knowledge exchange</td>
</tr>
</tbody>
</table>
RIS services for improving the integration of IWTs into intermodal chains – RISING

| Duration: | February 2009 – January 2012 |
| Partner Countries: | Austria, Belgium, Croatia, Germany, Greece, Hungary, Netherlands, Norway, Romania, Serbia, Slovakia |
| Project’s Targets: | RISING investigated how RIS can lead to useful solutions and services supporting complete transport chains involving IWW transport. For this purpose, existing RIS have being equipped with additional intelligent software modules. In addition, transport operators’ chain planning, execution and monitoring systems should gain the ability to implement such information into their planning and monitoring processes. On top of improved tracking and tracing (T&T) capabilities, new concepts, such as supply chain event management, have being used to facilitate automated chain monitoring such that chain managers are informed only when manual intervention is required for cargo to move properly. These new modules and their interaction with systems for chain planning and execution have being implemented according to the framework architecture and mode independent information exchange principles laid out in the Freightwise project. In order to make IWT a part of the co-modal transport chain, this mode must be able to supply at least the same quality services as all other transport modes. |
| Developed Solution: | In the RISING project new RIS services for transport and logistics operations have been specified, developed, programmed, tested and demonstrated. In the end, about 15 new RIS services have been elaborated for their use by the European transport and logistics companies. These new RISING services support the commercial IWT and multimodal operators in their daily business processes, such as transport planning and transport monitoring. Within the project the newly developed RIS services have been demonstrated in three main geographical areas in Europe: Rhine/Scheldt, Weser, Elbe, Danube |
| Relevance for ST4W: | High |
| Possibility for Interfaces: | Knowledge exchange |
Step Change in Agri-food Logistics Ecosystems – SCALE

<table>
<thead>
<tr>
<th>Duration:</th>
<th>January 2011 – September 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partner Countries:</td>
<td>France, Netherlands, UK</td>
</tr>
</tbody>
</table>

**Project’s Targets:** The partners of project SCALE worked across NWE to deliver new tools and frameworks to help businesses in the agri-food sector balance financial drivers with environmental and social considerations, improving both the efficiency and sustainability of food and drink logistics. The aim is to contribute to a much-needed change in our fast-developing world where the rise in the world’s population comes with an increased demand for food and subsequent rising food prices and fuel costs, extra production, and extra CO2 emissions.

**Developed Solution:** Tools developed on SCALE included:

- A new supply chain architecture that will help food companies optimise the financial, environmental and social costs of each unit of food delivered to the consumer
- A collaborative framework that will facilitate the development of multiparty collaborative relationships across the entire network to improve the overall sustainability of food and drink ecosystems;
- An ICT technical tool that will provide the necessary infrastructure and visibility to support food networks requirements across their complex networks to deliver long-term sustainability


**Relevance for ST4W:** Low

**Possibility for Interfaces:** Knowledge exchange
5. Overview of the present state of IT technologies used by IWW operators

The use of ICT in transport and logistics dates back to the 1960s. The first systems developed aimed at the electronic management of inventories, routing of transport and production scheduling. Thus, these systems used to operate as independent solutions without interactions. With the introduction of enterprise resource planning (ERP) in the 1990s, materials, labour, and finance were all integrated into the systems. This provided integral systems for companies’ internal processes. Later on, with the introduction of the Internet, new web-based systems emerged and communication between organisations was boosted. The main impacts of this last development on logistics systems can be divided into three categories:

- Business-to-Business (B2B) and Business-to-Customers transactions increased, leading to greater transportation demand
- New markets with more sophisticated transactions for “shippers to logistics service providers” and “logistics service providers to logistics service providers” emerged, promoting freight consolidation
- Logistics processes could be deeply optimised thanks to on traffic and real-time information

For the successful integration of ST4W tools it is important to analyse the new emerging technologies. Thus, in this chapter, the present state of ICT technologies used by IWW operators is described. The chapter organisation follows the TAP classification:

- Freight resource management systems and applications
- Terminal and port information and communication systems and applications
- Freight and fleet tracking and management systems
- Integrated operational and information exchange platforms, portals and marketplaces

5.1 Freight resource management systems and applications

Back-end freight resource management uses logistics software systems to support logistics tasks, including planning and forecasting covering all logistics areas, i.e. in-house logistics, warehouse, transport and supply chain management.

Current trends in systems and applications are targeting the enablement and the facilitation of multimodal transports for complex European-wide or global transport chains, crossing the primary ST4W domain of interest. ST4W is focusing on IWW and the benefits of RIS, as they provide information and services integrated with back-end operational enterprise systems and applications of the LSPs and the stakeholders of the overall river transportation and logistics ecosystem. Operating in a multimodal domain which comprises different transport means, support for sophisticated planning and control is expected.

Further, green logistics trends are finding support and are accelerated by IWW logistics options as part of synchronomodal/multimodal transport and dynamic and adaptive logistics chains, and they certainly play an important role in EU green policies. The top-level logistics-related drivers to adopt a comprehensive IT solution for transportation logistics, forming the basis of most solution selection strategies, are the following:

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80. Yoshimoto, Nemoto (2005)
Accuracy in the planning and control of logistics processes, requiring the use of precise scheduling, event management and identification.

Reliable and resilient logistics systems in the case of unforeseen incidents requiring accurate capacity planning and the correct dimensioning of resources used. Solutions for better planning also involve the use of simulation models.

Responsiveness in the order-fulfilment cycle time, covering delivery optimisation, scheduling and routing, and management of returns.

Adaptability and agility to minimise value at risk, and to address unplanned actions and use of resources.

Interoperability between different systems for data exchanges and collaboration and via the use of industrial standards in information exchanges (GS1, UN/CEFACT, EDIFACT, WCO etc.) on open standardised interfaces.

For SMEs of considerable size to larger enterprises, the solutions commonly used involve software packages such as ERP systems, warehouse management systems (WMS), transportation management systems (TMS) and supply chain management (SCM) systems.

The goal of an ERP system is to support the efficient use of the enterprise resources (e.g. capital, machinery, vehicles and personnel). ERP systems today are a highly evolved package, extending over and covering many business processes and functions, comprising various modules to support planning, coordination and management at the managerial and operational level.

Hence, besides the core logistics applications involving inventory management or disposition, ERP systems offer components for many business functions, such as finance, accounting, controlling and manufacturing. Contemporary ERP systems can adapt to business process changes, are flexible, and are based on open technical standards so that they can interoperate, exchange information and integrate with other enterprise systems, including the systems of collaborating organisations and business partners, forming an end-to-end supply chain.

![Extended ERP Functions](image)

Figure 3: ERP systems, CORE and extended business functions coverage

WMS have the task to support the operation and the optimisation of enterprise warehousing systems. Contemporary WMS offer advanced management and optimisation which are far beyond

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the expected stock management functionalities of a specific warehouse, integrating software components for the control, monitoring and optimisation of complex warehousing configurations and distribution. WMS core business functions support certainly covers the management of Stock Keeping Unit (SKU) quantities and storage locations, the controlling of the means of transport and their scheduling, reporting and visibility on the resources usage and include the strategic and optimised tactical planning and execution monitoring and re-planning in the daily business operations. The available functions support and the design philosophy of a modern WMS originate in ERP systems, combining and extending support for SCM and transport management such as an entire order fulfilment, covering processes for receiving and shipping.

Further, contemporary WMS integrate subsystems for communication with a picker, systems to identify the products (e.g. radio frequency readers, handhelds). Such functions include route planning and scheduling, vendor managed inventories, billing and multiclient scenarios.

Figure 4: WMS

TMS enable the management of complex transport chains including transport-related logistics requiring complex multimodal route planning, addressing the increasing complexity of global logistics chains of consignors, LSPs, and consignee collaboration over their external collaborating logistics processes.

Figure 5: TMS, core and extended functions
Modern TMS support the business functions of planning, monitoring and control, and the optimisation of transport networks and logistics chains. Their core TMS support functions include order management, scheduling, transport planning and optimisation, T&T as well as fleet and resource management, and covering the planning and optimisation of procurement and distribution, taking into account existing cost and/or time constraints, multimodal transport chains and their planning, and the optimisation of delivery routes.

Further, TMS (besides transportation planning) extend to operations support, fully covering transport execution i.e. the control and monitoring of the realisation of the resulting transport processes. TMS also integrates mobile units handling information coming from data streams, including the means of transport means and load handling accessory equipment.

5.2 Terminal and port information and communication systems and applications

A port community system (PCS) is an electronic platform that connects the multiple systems operated by a variety of organisations that make up a seaport or airport community. It is shared in the sense that it is set up, organised and used by firms in the same sector – in this case, a port community.

Nevertheless, PCSs have extended far beyond seaport or airport communities, including inland shipping, rail or other modes of transport. Thus, an updated and more accurate definition is: “A PCS can be defined as an entity delivering information to supply chains operating in the port. The PCS is responsible for data supply, data control, data distribution and data conversion.”

In Europe, PCSs have a long tradition; the first were established in ports in Germany, France and the UK and began operation in the late 1970s and early 1980s. Countries such as the Netherlands and Spain started their PCSs in the 1990s or at the turn of the century.

Key drivers for the establishment of PCSs were, on the one hand, the need for a standardised communication platform in order to improve the systems in terms of punctuality, reliability and costs and, on the other hand, the need to increase competitive position among ports.

The number of ports connected to a PCS varies from one to many. Smaller ports in particular often join forces to set up a PCS or to connect to an already-existing PCS of a larger port or ports.

A PCS:

- Is a neutral and open electronic platform enabling the intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the seaports’ and airports’ communities
- Optimises, manages and automates port and logistics processes through a single submission of data and connecting transport and logistics chains

A PCS system operator:

- Is an organisation that is public, private or public/private and that operates and maintains a PCS and where the PCS represents the core of that organisation’s business
- Has a board, or some form of steering committee, that is made up of representatives from different internal and external groups within the port and logistics community
- Has service level agreements (SLAs) with PCS users to manage the electronic exchange of information between different parties on their behalf
PCS connects multiple stakeholders: forwarders, customs, consignors, ocean carriers, inland carriers, stevedores, port authorities, consignees, port services and shipping agents.

**S-One (HAROPA)**

HAROPA brings together the ports of Le Havre, Rouen and Paris. A true river hub, HAROPA/Ports de Paris is a network with 70 ports along the Parisian waterways, and it provides a system not only for international and regional exchanges but also for a significant part of intra-regional traffic.

HAROPA and its partner ports have implemented the “port single window” system which manages the flow of information of goods passing through the terminals. Initially developed for maritime transport, this system is now extended to river transport.

The automation, optimisation and management of processes through a single submission of data and connecting transport and logistics chains as well as the dematerialisation of documents offered by the PCS speeds up information exchanges and, by extension, goods processing. Not only is the PCS a facilitator of different business processes, but it is also interoperable with the users’ private information systems. PCS goods tracking/tracing modules ensure the integrity of the logistics chain while guaranteeing data confidentiality.

The assets are multiple:

- T&T of the entire supply chain
- Interconnecting of customs and port professionals
- Simplifying of procedures
- Ensuring data protection and security
- Protecting the environment (zero paper)

HAROPA is using S-One, the “next-generation” PCS developed by SOGET, defined as a collaborative platform enabling supply chain operators to streamline all foreign trade-related exchanges on a national level.

This system is open to everyone, but it is not free. The users are mainly port freight forwarders and transport organisers. The system is also not easily accessible for chargers with occasional flows. In addition, this system is an extension of maritime software and has been implemented in “small” river ports thanks to the work already done by HAROPA. It would have been a lot more complicated and expensive to set up individually.

**RPIS**

RPIS was developed by a consortium comprising RheinPorts Basel-Muhlhouse-Weil with its 7 container ports, Rheinhäfen Karlsruhe and the Independent Port of Strasbourg. This 3-year project took into account the requirements of the port operators, IWT companies and shipping companies.

The system includes a uniform barge reservation system, a container data exchange in real time and an electronic customs clearance system.

The first module of RPIS consists of a container barge scheduling and berth booking system. This module is based on Antwerp’s Barge Traffic System (BTS).

BTS is an Internet application developed several years ago by the port of Antwerp as a unique traffic scheduling and berth booking system for container barges. It offers significant advantages for barge
and terminal operators, including more transparency and better traffic control which in turn yield important time savings whenever a barge has to call at several sites within the port.

RheinPorts had to deal with a similar situation of several calls per barge, and so it began looking for an information platform to permit data transparency. Its system and supplier evaluation procedure resulted in using BTS, the solution offered by the Antwerp Port Community System as a foundation for the first RPIS module.

The RPIS will form the basis of an Upper Rhine traffic management platform. There are plans to form a separate company that will be tasked with its operation. In time, it will also be made available to other terminals in inland shipping as a standard system.

The Upper Rhine traffic management platform project aims to develop an innovative IT platform for the ports of the Upper Rhine, allowing centralised coordination and efficient traffic organisation. This will take the form of an integrated system interfaced with the IT applications of terminal operators, river operators, customs services and river information systems.

The results expected by the introduction of the platform are:
- Improving the logistics processes along the Rhine as a central corridor of the TEN-T
- Increasing the competitiveness of river transport compared to rail and road modes
- Reducing CO2 emissions by reducing boat waiting times and increasing the load factor of river units

Portbase – port of Rotterdam

The port of Rotterdam is Europe’s largest seaport. The port owes its leading position both to its outstanding accessibility for sea-going vessels, its intermodal connections, and the 180,000 people working in and for Rotterdam’s port and industrial area.

The port of Rotterdam is a place where hundreds of parties come together and work together to get goods from A to B as efficiently, quickly and safely as possible. This means everything must run like clockwork. In Rotterdam, coordination and the exchange of information take place efficiently and easily via Portbase.

Portbase offers over 40 different services for all the links in the logistics chain. Previously, companies had to organise matters such as pre-reporting a vessel; seeking the status of a shipment; handling export documentation; loading/unloading papers; or communication separately and by e-mail, fax or telephone. Thanks to the PCS, those days are over. Everything is now merged into a single system. This results in increased efficiency, lower planning costs, better and transparent planning, faster handling and fewer errors.

The services within the PCS focus on all port sectors: containers, break bulk, dry bulk and liquid bulk. All the links in the logistics chain can easily and efficiently exchange information through these services. The PCS offers each of these target groups its own package of tailor-made services thanks to three main components:

- Application layer services
- A platform with common facilities for all services
- A central database where all information coming from companies and governments is exchanged
Portbase is a non-profit organisation. Companies only pay a fee for the use of services with demonstrable added value. In relation to the benefits, these costs are relatively low. Some services are also free of charge. The funding of services with a particular strategic importance for the port is channelled through the general revenues of the shareholders’ Port of Rotterdam Authority and the Amsterdam Port Authority.

**DAKOSY – port of Hamburg**

The PCS for the port of Hamburg is operated by DAKOSY and is one of the most advanced port IT systems in the world. The digital platforms for import processing Import-Message-Platform and export processing Export-Message-Platform enable all businesses and authorities involved in cargo handling to perform fast, efficient and largely automated processes in seaports as well as to perform perfectly integrated intermodal hinterland handling of all modes of transport.

Under the banner of the PCS, Dakosy offers solutions that support additional processes, including customs export handling (ZAPP-Sea), hazardous goods management (GEGIS), and managing the arrival and departure paths of large ships on the Elbe and in the port of Hamburg (PRISE). DAKOSY carrier services solutions provide corresponding platforms and interfaces which enable such transactions as the booking process with carriers (eBooking), the transmission of container weights to carriers (VGM-Portal), and Europe-wide port registration according to Directive 2010/65/EU (eDeclaration).

**PORTNET – port of Singapore**

The Port of Singapore Authority (PSA) was formed on 1 April 1964 to take over the functions, assets and liabilities of the Singapore Harbour Board. It was operating five maritime gateways by 1990, including Keppel Wharves, Jurong Port, Sembawang Wharves, Tanjong Pagar Container Terminal and Pasir Panjang Wharves. To ensure that Singapore’s port would remain responsive to industry developments and marketplace demand, PSA was incorporated on 1 October 1997 and it became known as PSA Corporation.

Portnet.com, a subsidiary of PSA Corporation, helps the entire port and shipping community increase productivity and efficiency through the greater use of information technology and the Internet. Through constant technological innovation, Portnet.com has consistently been positioned at the forefront of e-business operations in the maritime and shipping industry.

A PSA flagship IT solution, PORTNET® is the world’s first nation-wide B2B port community solution. PORTNET has provided the logistics industry with a single sign-on network portal. Through it, PSA has connected shipping lines, hauliers, freight forwarders and government agencies, helping them manage information better and synchronise their complex operational processes.

From managing complex transhipment processes of shipping lines (EZShip®), supporting slot exchanges among alliance partners (ALLIES™), enabling companies to monitor performance and make critical business decisions (TRAVIS™), and integrating port documentation seamlessly with the haulage processes and workflow (Haulier Community System™) to providing a documentation portal between shipping lines and shippers (CargoD2D™), PORTNET simplifies and synchronises millions of processes for customers moving their cargo through Singapore.

Over 10,000 integrated users rely on the system’s unparalleled capability to provide real-time, detailed information on all port, shipping and logistics processes crucial to their businesses. PORTNET processes more than 220 million transactions a year.
Key services managed by PORTNET include berth application marine, transhipment/import, delivery/export, haulier/depot, cargo, dangerous goods, vessel/container info, car/cargo info, proactive management, mobility, business integration and trade permit declarations.

5.3 Freight and fleet tracking and management systems and applications

The purpose of this section is to describe to what extent existing solutions enable the tracking, monitoring, and controlling of cargo and vehicles in order to reduce uncertainty in multimodal transport chains; in other words how an end-to-end seamless visibility exists with IWT in a multimodal environment. When a shipper subcontracts the transport execution to a freight forwarder, a centralised organisation enables the use of a centralised control tower solution, facilitating a first level of visibility. In fact, the different modes of transport use technologies working in silos, and there remains a lack of visibility even in this case. This is why decentralized networks exchanging harmonised data will help implement a better interoperability between the systems of the different partners of the multimodal chain.

As ST4W’s field of action is IWT, using roads on land for pre-shipment and post-shipment, we will describe both the RIS and the existing tracking technologies for roads. After that, we will describe freight tracking technologies, and to what extent all these tracking systems are able to communicate.

RIS

RIS are information services for traffic and transport management for waterways navigation including their links to other modes of transport. RIS aims to improve safety and efficiency in IWW traffic in the direction of achieving GHG reduction and environmental friendliness of transport.

The Directive 2005/44/EC83 (European Parliament and Council of the EU, 2005) is regulating RIS, providing a Europe-wide framework for the implementation of the RIS concept and the compatibility and interoperability of current and new RIS systems across Europe. The Directive defines rules for data communication and RIS equipment as well as the minimum level of RIS services for RIS implementations.

RIS streamlines information between public and private parties, and this information used in different applications and systems for enhancing traffic and transport processes. The information is shared based on harmonised, standard information and communication systems messages and interfaces. Hence, RIS promotes standardised information exchanges for collaboration between businesses and administrators, fully covering transport operations so that they can be optimised for inland navigation, enabling the creation and the efficient operation of intermodal logistics chains.

The RIS Guidelines (CEC, 200784) describe the principles for planning, implementation and the operational use of RIS and related systems applying to all cargo vessels, passenger vessels and pleasure craft.

Key technologies

There are four RIS key technologies, based on standards that have been developed thanks to the work of RIS expert groups:

- Vessel Tracking and Tracing (VTT)

84 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32007R0414
Inland Electronic Chart Display and Information Systems (Inland ECDIS)
Electronic Reporting International (ERI)
Notices to Skippers (NtS)

VTT
For VTT Inland Automatic Identification System (AIS) are used. This is a standardised procedure for the automatic exchange of data between ships and between ships and shore installations.

This standard is a cooperative procedure; therefore, all users wishing to participate in the system must be equipped with an AIS device. Vessels fitted with AIS transmit and receive information on an automatic and periodic basis to and from other vessels equipped with AIS. Information regarding the vessel and its current navigation data are exchanged, including the identity of the vessel, and its exact position, course and speed, with additional vessel-specific data.

Data standards and harmonised procedures are required to ensure a good interoperability of AIS devices from various manufacturers. These standards define:
- Functional and technical requirements for inland AIS devices,
- Specification of AIS messages for the exchange of messages between inland AIS devices via radio and
- Specification of AIS data sets for data exchange between inland AIS devices and connected applications.  

AIS do not replace navigation-related services such as radar target tracking and VTS because AIS detects and tracks only vessels fitted with the system. AIS and radar complement one another due to their different characteristics.

In addition, we can see that for tracking deep sea vessels, most logistics companies use MarineTraffic which tracks deep sea vessels based on AIS data. However, MarineTraffic systems integrate diversified sources of tracking information, including illegal sources. All deep sea vessels and barges for IWWs have one or more methods of communications which they can use to specify their locations. These include an AIS transmitter and receiver, a VHF radio transmitter and receiver, a long-term evolution connection on a mobile phone, and the Internet via a mobile operator.

Inland ECDIS
Inland ECDIS is a tool for the display of electronic inland navigation charts and additional information. One of the aims of this technology is to increase the safety and efficiency of inland navigation. In addition, inland ECDIS enables skippers to reduce the workload when navigating the ship as compared to traditional navigation and information methods.

The inland ECDIS standard provides a uniform basis for electronic inland navigation charts, complementing other RIS standardised technologies such as inland AIS transponders. This standard describes the technical and operational requirements, testing methods and required test results for inland ECDIS applications.  

inland ECDIS has an information mode which is basically an electronic chart used to guide and provide information about the waterway. It is not intended to navigate the vessel. If connected to a

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85 http://www.ris.eu/expert_groups/vtt
87 https://www.marinetraffic.com/
88 http://www.ris.eu/expert_groups/ecdis
GPS device, the chart can be adjusted automatically in a way that the vessel’s position is fixed in the centre of the screen.

A more helpful way to use inland ECDIS is with the navigation mode which couples the use of a radar and ECDIS chart, enabling the detection of other entities and hazards such as floating logs.89

ERI
Electronic reporting is an electronic messaging technology enabling an automatic exchange of information on vessel and cargo data. The messages ensure a fast dispatch and transparent procedures with appropriate controls and simplified water transport processes for all those participating in transport operation, including authorities, lock operators, emergency services, port operators and fleet operators.

The standard for electronic ship reporting in inland navigation:
- Describes the messages, data items and codes to be used in electronic ship reporting for the different RIS services
- Proposes the basic and most important recommendations for electronic reporting
- Addresses the relationship between private parties (shippers, skippers, terminal operators and fleet managers) and public parties (waterway authorities, public ports)90

NTS
Waterway administrations have to inform users about issues regarding the waterways, and particularly those influencing safety and accessibility. NTS communicate, for example, the status of the IWW infrastructure (e.g. bridges and locks), navigation aid failures, temporary blockages of waterway sections or other types of infrastructure, works, water level and water depth information, ice information and weather messages.91

The NTS international standard provides a standardised data format which can be used both for publishing notices on the Internet (pull services) or for distribution by e-mail (push services). This is an international standard for the distribution of notices to skippers on inland shipping routes as established by the Commission Regulation (EC) 416/2007 of 22 March 2007.92

The aim of this standard is to:
- Provide automatic translation of the most important contents of notices into all the languages of the participating countries
- Provide a standardised structure of data sets in all the participating countries in order to facilitate the integration of notices in voyage-planning systems
- Provide a standard for water level information
- Be compatible with the data structure of inland ECDIS in order to facilitate the integration of notices to skippers in inland ECDIS
- Facilitate data exchange between different countries
- Ensure the use of standard vocabulary in combination with code lists93

90 http://www.ris.eu/expert_groups/eri
91 http://www.ris.eu/expert_groups/nts
Different kinds of messages are standardised, particularly:

- Fairway and traffic-related messages
- Water-level-related messages
- Ice messages
- Weather-related messages

**Benefits**

The major economic benefits of the implementation of RIS are increased competitiveness, optimised use of infrastructure, improved safety, reduced carbon emissions and increased energy efficiency. Other benefits include:

- Information about vessel position and estimated arrival times, the type of cargo on board the vessel, and the quantity of cargo
- Single interface with several inland ports
- Faster and automated business processes
- Lower administrative costs

**Services enabled by RIS key technologies**

The principal services enabled by RIS technologies are: local traffic management, voyage reporting systems, lock and bridge management, calamity abatement support, information for law enforcement, statistics data collection, voyage planning, intermodal port and terminal management and cargo and fleet management. This section will briefly describe which functionalities each offers.

**Local traffic management** is provided by VTS. VTS centres for RIS are installed at critical points along the European waterway network, and are being implemented by authorities with the aim to improve the overall safety and efficiency of vessel traffic and to protect the environment. Local traffic management interacts with the vessel traffic and responds to traffic issues arising in a VTS area. The information required by local traffic management is gathered by shore-based radar stations, fed into an inland AIS network which provides additional information, such as the identities and the accurate positions of vessels.

**Voyage reporting systems** provide information for planned and actual voyages. This information includes the descriptions of vessels and their cargo, and all necessary information about the traffic, such as possibly unsafe traffic conditions, to increase the efficiency and the safety of the traffic flow.

**Lock and bridge management** reduces waiting time and thereby the bottlenecks in IWWs, facilitating a reliable and synchronised passage of vessels through locks and bridges. It also provides a strategic traffic image to support operators in their optimal planning of locking operations by correctly estimating the time of arrival (ETA) vs the requested time of arrival (RTA) for vessels. Lock operators can inform skippers on the validity and feasibility of RTAs and the possibility to save on fuel by selecting more economic speeds for the voyage.

**Calamity abatement support** registers transport data for the vessel journey during the voyage; this enables the RIS authorities to provide accurate information and reliable details in the event of accidents to rescue teams. Further, co-ordination of rescue teams is assisted by electronic navigational charts and the tactical traffic image.

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94 http://www.ris.eu/expert_groups/nts
Information for law enforcement is in support of inland navigation, in cross-border management and customs, and in compliance with the regulations for traffic safety and environmental protection.

Statistics data collection is for IWW traffic and freight. RIS collects data electronically which can be used by skippers and terminal and lock operators. Such statistical data is also potentially of interest to waterway authorities, international organisations and businesses related to IWW services and may be used for tactical and strategic planning.

Voyage planning is performed by skippers and fleet managers who need fairway information to make accurate voyage plans, and includes the optimal route planning, the draught and the ETA for a vessel. Transport management is the management of the transport chain having as stakeholders the freight brokers and transport service managers. Transport management focuses on the:

- Improvement of the performance and the resource utilisation of a contracted fleet
Monitor and control of contracted transports and the improvement of reliability managing deviations in voyages and cargo, and handling incidents in transports

Billing of transportation and logistics services

**Intermodal port and terminal management** provides operators information about the ETA of a vessel and the related cargo for accurate resource planning in order to optimise terminal utilisation, enabling the smooth vessel-related operations through the terminal facilities. This achieves better slot management and reduces transhipment time. Further, real-time dynamic interaction and re-planning of schedules enables adaptation to insufficient terminal capacity (e.g. in peaks or unplanned events), by terminal operators collaborating with skippers and managing both ETAs and RTAs.

**Figure 8:** RIS-related business functions

**Cargo and fleet management** provides accurate information for vessel cargo (i.e. vessel-available loading capacity in real time), actual vessel positions, RTAs and ETAs, the cargo load transported, cargo waiting to be shipped, and terminal information.

**Analysis of RIS-related business services and functions**
The related business services and functions of a RIS have been analysed in the RISING95 project, targeting logistics companies, port and terminal operators, and fleet operators. The RISING services focus on:

- Shipping and transport planning: Identifying transport connections and routes for IWT and mapping it to voyage plans

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95 www.rising.eu
**Transport monitoring:** Monitoring planned versus actual status information to identify possible issues, deviations and delays, and to take mitigation actions

**Shipping and transport planning**

Based on RIS information the planners examine transport conditions for a transport to be feasible for specific vessels on routes over waterways. Data and relevant information include the transhipment capabilities of terminals and the exact transhipment locations. Of interest are also the synchromodal, multimodal capabilities of terminals, and their inclusion on the overall transportation plan for advanced CO2 reduction and costs optimisation.

A shipping company generates and uses this type of information, also related to the planning and execution of a transport service, including vessel and transportation equipment details (e.g. capacities, types and fuel), cargo characteristics, and artefacts such as a schedule ETA and a vessel RTA. The following figure shows the shipment processes from the viewpoint of an LSP, their RIS-related functions, and their related business objects which may be paper or electronic documents and reports, and/or data entities of a RIS-enabling information system stored in a database.

![Shipment planning diagram](image.png)

**Voyage planning:** Voyage planning involves the detailed freight transport planning on IWWs and in IWT operations. This includes the detailed planning of a voyage such as determining the best route, choosing the vessel-type including the optimal vessel type fit for the plan as regards capacity, and figuring out the fuel consumption and GHG parameters.

![Fleet scheduling and voyage planning diagram](image2.png)

**Loading planning:** Skippers are responsible for the loading of a vessel, respecting the safety regulations, the characteristics of the vessel and the stowage plan. Any loading deviations (e.g. in weight and dimensions) are communicated to other relevant stakeholders.
Clearance: Barge operators and skippers should know the typical vertical clearance under bridges in order to allocate cargo. RIS provides dynamic clearance information; however, water levels change and to make the best use of a vessel capacity while respecting the legal minimum stability limits, voyage plans must take this into account.

Berths and terminals: This involves the collaboration plans between IWT operators and inland or sea terminals based upon the ETA and RTA.

Transport monitoring
LSPs need to be in control, monitoring the execution of the planned voyages, and must be able to react to events such as unexpected delays. Operators can usually sense forthcoming delays, such as the interruption to the schedule due to a short-term lock closing. Via re-planning a solution is to choose and adapt the voyage speed and to update RIS and terminals for a plan update by recalculating the ETA and RTA.
A vessel skipper is responsible for the detailed voyage plan, and creates it on board using an electronic chart display and information system. With the use of AIS and vessel-tracking facilities, skippers record deviations and initiate corrective actions informing all stakeholders. A skipper also allocates overnight berths based on berth availability.

T&T: T&T of cargo requires information about the position and status of the vessels in order to define the current location and status of the given cargo unit.

Traffic information management: The actual traffic information is highly important for traffic management and controlling. IWT RIS services advance the reliability, responsiveness, agility and cost-efficiency of logistics processes. Actual and forecast information is vital for all modes of transportation, especially when implementing multimodal and synchromodal scenarios that use IWT options to improve cost-efficiency and to reduce the environmental carbon footprint.

Lock Status: Locks are part of the RIS infrastructure and play a significant role in IWT. Lock management is responsible for providing the status of locks and their availability during certain time periods. Locks are considered important waypoints in transport routes, as they are the places where the most unpredictable delays happen. Hence, up-to-date lock status information and traffic data are important for the IWW and transport logistics users passing through locks.

NtS: NtS provides information about deviations from planned voyages. NtS concern lock statuses, and water-related messages containing data about vertical clearance are based on the data from the water level modelling sources which are necessary for the proper functioning of vertical clearance services.

Infrastructure utilisation: Port and terminal operators need to monitor the utilisation of their capacities (e.g. berthing space and equipment) to react to unexpected delays.

Road transport fleet tracking
The tracking of road vehicles (trucks) provides basic information about the trucks, from location and fuel consumption to software services such as fleet management or transport management. The basis of the technology is generally a GPS which is a satellite-based radio-navigation system providing geo-location and time information to a GPS receiver.96

GPS fleet tracking software works thanks to GPS hardware embedded in the vehicle, enabling the tracking of vehicles in real time. The GPS system provides users access to real-time updates and alerts using data that is sent directly from the vehicle to the software operator.97

The main objective of an FMS is to improve the management of vehicle fleets and to reduce their operating costs:

- Operations: FMS use metrics to monitor different parameters such as driving routes, idling times, driver downtimes, vehicle locations and more.
- Safety: FMS can also contribute to an improvement in vehicle safety. The software can identify instances of unsafe driving practices such as hard braking or excessive driving hours.

96 https://www.loc.gov/rr/scitech/mysteries/global.html
Security: In case of an accident or theft, both the company and policing authorities can use fleet tracking software to monitor and track vehicles. In addition, road vehicle tracking systems can feed transport planning and execution software. For example, the GET Service platform that focuses on this combination of technologies considers the following scenarios:

- **Real-time planning:** This includes real-time insight into current delays of connecting modes of transportation, current handling times at terminals and current administrative delays.
- **Optimal resource selection:** This includes real-time insight into the available transportation capacity in a certain area which significantly reduces empty miles, because the closest transportation resource can easily be selected.
- **Executing changes during transportation:** This includes real-time insight into the status of the transportation plan, disruptions of the plan and alternative transportation options. By facilitating the execution of the tasks associated with changing the transportation plan, transportation times can be reduced.

**Freight tracking systems**

Generally, freight tracking systems do not need to include real-time communication, as the last known position is sufficient to track goods. For example, a barcode label stuck on a logistics unit will be read when a transhipment point or gate is passed, in order to register its passage. Or a passive RFID tag would be used in a warehouse to scan the boxes as they are loaded on a truck. In addition, the truck itself is tracked in a different system using GPS with its own features and software.

If necessary, a higher level of technology is used, for example with the following conditions:

- The transport of food products under controlled temperature conditions, with active RFID (with an embedded battery which enables capturing the temperature information thanks to a dedicated sensor)
- Use of a container security device: ensuring the integrity of the container along the supply chain and facilitating trade and customs processes, thanks to electronic seals
- Use of asset management: utilizing IoT sensors, with many types of sensors available, such as acceleration, temperature, humidity, pressure and proximity sensors, which can be utilised for different use cases. The sensors are attached to assets in order to gather data which is pushed to a cloud platform. This happens at a certain frequency (e.g. every 10 minutes), depending on the technology and settings used for the data transmission. The data is then analysed and transformed into actionable insights about the assets’ usage, location, environment and condition.

IoT enables the management of assets such as locations, inventories, usage hours, material flow and environmental conditions (temperature) to generate a wide pallet of information for the decision making, such as automatic reporting, predictive analytics, automation of tasks, real-time information, and reminders and alerts.

**Standardisation and interoperability**

From the point of view of end-to-end seamless visibility, the main issue remains that these different technologies are working in silos without interoperability between the different systems and devices. Using common standards will be one of the main challenges in order to increase trans-modal visibility. GS1 is a not-for-profit, world-wide organisation that develops and maintains the most

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99 http://getservice-project.eu/
100 https://trackinno.com/2018/02/05/internet-things-iot-brings-asset-management/
widely used supply chain standards system in the world. GS1 standards improve the efficiency, safety and visibility of supply chains across multiple sectors.\(^{101}\)

**GS1 system of standards**

The GS1 system of standards is an integrated suite of technical and application standards that allow end-user systems to conform to interoperate and thus includes standards for automatic identification and capture and standards for electronic information exchange (eCom, EPCIS, GDSN).\(^{102}\)

GS1 promotes the logistics interoperability model (LIM)\(^{103}\) which aims to establish business interoperability and visibility in transport and warehousing business processes. The LIM:

- Has been developed by the GS1 Logistics Forum which includes representatives of different parties of the supply chain
- Is an interchange standard for information based on global GS1 standards, GS1 data keys (GSIN, GRAI, SSCC), and GS1 EANCOM and GS1 XML in alignment with UNCEFACT. GS1 is intended to scale from large corporations down to SMEs and is focused on visibility
- Introduces a collaborative approach to interoperation, based upon the key players in supply chain systems, and most notably to retailers, manufacturers, materials suppliers and logistics providers in warehousing and transport services
- Is the framework of common business processes and related data communications and interchanges on all levels of interoperations from master data alignment to financial settlement
- Describes the high-level business processes and a comprehensive set of transactions that occur in these processes

![Figure 13: Data exchanges in GS1](image)

LIM\(^{104}\) covers the following business functions (in version 1):

- Procurement
- Planning
- Warehousing
- Transport
- Financial settlement

The scope of the LIM applies to continental transport which is basically road transport. Future versions will cover inter-modal transport: maritime, rail, air and enhancement of roles, and customs.

\(^{101}\) [https://www.gs1.org/sites/default/files/gs1standards_in-maritime.pdf](https://www.gs1.org/sites/default/files/gs1standards_in-maritime.pdf)

\(^{102}\) [http://www.gs1.org](http://www.gs1.org)

\(^{103}\) [https://www.gs1.org/transport-and-logistics](https://www.gs1.org/transport-and-logistics)

\(^{104}\) GS1 (2018)
In LIM actors in logistics business processes and services assume the role of either the LSP or the logistics services client. LSPs include transport service providers, carriers, freight forwarders, warehouse service providers and other service providers such as customs brokers. Regarding commercial transactions, the roles assumed are the consignors and the consignees.

GS1 standards for data exchanges can be categorised into three types:

- **Master data**: Persistent, non-transactional data that describes the trade items, parties and locations, all of which are identified by GS1 keys.
- **Transaction data**: Data describing the execution of a trade agreement, consisting of trade transactions, confirming the execution of a previously made business agreement, from order to final settlement, also making use of keys.
- **Event data**: Data describing the movement of trade items, logistical units and assets; details are provided for the activities in the supply chain, identified by keys and describing where these objects are in time and why throughout the supply chain.

For the exchange of collaborative information, GS1 uses two different alternatives:

- **EDIFACT**, as specified by UN/CEFACT; the data is defined in the Trade Data Element Directory, in logical groupings in the EDCD (EDIFACT Composite Data Element Directory) and EDSD (EDIFACT Segment Directory).
- **GS1 XML**, defining a set of generic rules for encoding electronic documents. UN/CEFACT and GS1 XML share many rules, but they also have variances. Messages are constructed according to the XML Design Rules for GS1, which are partly based on the UN/CEFACT XML Naming and Design Rules. The data is defined in the GDD (GS1 Global Data Dictionary); shared with UN/CEFACT are the UN/CCL (Core Components Library) including ABIE’s (Aggregated Business Information Entities), which describe logical groupings of data, and the UN/CEFACT Standard Business Document Header, which defines the contents and parameters of the message.

The GS1 Global Visibility Framework is an integrated suite of global standards that, when used together, enable the visibility of physical assets (e.g., trade items, reusable assets, fixed assets and work in process) through common ways to uniquely identify, capture and share information relating to their movement or their state. The framework provides:

- Globally standardised “supply chain event” data structures for end-to-end visibility
- A common business vocabulary
- Standards for (secure) connectivity, data storing, sharing and searching
- Discovery services supporting supply chain events searches
- A decentralised data storage architecture using EPCIS event repositories

GS1 supports identification keys to provide efficient ways to access information about items in supply chains and to share this information between trading partners. GS1 includes the following identification keys:

- **GINC**: Global Identification Number for Consignment.
- **GLN**: Global Location Number. GLN is used to identify a location. Locations in GLN refer to physical locations (e.g. a warehouse) or to a legal entity (e.g. a company or customer). The GLN can be used in conjunction with a bar code or GS1 EPC tag.
- **GTIN**: Global Trade Item Number. The GTIN is used as an identifier for trade items.
- **GSIN**: Global Shipment Identification Number.
- **GEPIR**: Global Electronic Party Information Register.
- **SSCC**: Serial Shipping Container Code.
- **GS1 EPCglobal**: Global standards for RFID object tags.

**Figure 14**: GS1 standards for identification

Traceability systems can use GS1-approved barcodes and EPC/RFID tags to encode GS1 identification keys that uniquely identify products, trade items, logistics units, locations, assets and service relations worldwide. Additional information such as best-before dates, serial numbers and lot numbers can also be encoded into barcodes or EPC/RFID.

**Barcodes**: These enable the electronic reading of business processes. A barcode is a number used to identify goods, services, assets and locations worldwide. The marking of traceable objects is driven by the level of identification. Batch/lot-level or serialised identification are dynamic types of data and therefore cannot be included in the artwork of the packaging. This means that adding dynamic data in a barcode will have an impact on printing and packaging speeds. Traditionally, barcodes on consumer units were used for point-of-sale scanning and only contained the GTIN, also known as the EAN or UPC. With evolving product safety regulations and product information requirements, other types of data are making their way into the barcodes on consumer products. Besides the batch/lot identification (ID) and/or serial ID, these may also include the expiration date, the best-before date etc. The proper linkage of the barcode, the related data and the produced instances of the trade item is a key aspect.

**EPC/RFID**: EPC/RFID tags are serialised. A special aspect is that EPC/RFID tags will often be pre-written, requiring the link between the issued serialised identifier and the associated data to be recorded afterwards.

**Figure 15**: GS1 standards for barcodes and EPC/RFID

**LIM building blocks**

In this section, of the 5 LIM building blocks (procurement, planning, warehousing, transport and financial settlements) the more transport-logistics-relevant models are described, i.e. planning, warehousing and transport. All process and data descriptions can be found in the GS1 LIM standard description document.105

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105 https://www.gs1.org/docs/EDI/GS1_Logistics_Interoperability_Model_Application_Standard.pdf LIM 1.1
Planning
Planning focuses on future warehousing or transport activities and aims at ensuring the capacity to fulfil requested services. For the warehousing capacity, this applies to the storage volume and resource capacity. For the transportation capacity, this applies to transport volumes and timings.

The capacity planning is driven by the monthly and/or weekly forecasted shipments/pallets/picking until the actual demand (shipment) is released to the warehouse and/or the transport provider via delivery instructions (for transport booking, order picking, packing and loading). In some cases actual planned shipments are available to increase forecast accuracy.

Message exchanges (transactions) include warehousing requirements, transportation capacity requirements, transportation capacity booking and confirmation, and the transportation capacity plan.

Transport
Transport is the movement of goods from factories to warehouses or depots (collection), the movement of goods from warehouses to the customer delivery locations (delivery), and the monitoring of these movements.

While the LIM model aims to be transport-mode independent and it can be applied to road, rail, ocean and air, it is focused on continental transport modes. For road transport, this includes full truck load transport, less-than-truck-load transport and parcel distribution.

Message exchanges (transactions) include transport instruction and response, pick-up request and confirmation, transport status request and notification, drop-off request and confirmation, and transport accompanying documents.

http://www.gs1si.org/Portals/0/GS1_Dokumentacija/GS1_Publikacije/Brosure_GS1_ANG/LIM_Foundation_Report.pdf for LIM 1.0
Warehousing

Warehousing is the receipt, storage and preparation of products for customer delivery based on orders. It also includes all involved administrative activities. Within storage, this also covers the control of stocks including traceability in the warehouse.

The return flow of products and materials in the supply chain is also included, such as product recalls and reverse logistics for empty pallets or crates.

On top of these warehousing activities, additional services may be rendered, such as dry filling, repacking for promotions, re-stacking or re-labelling. These are often defined as value-added services. As long as the GTIN of the serviced item stays the same, this is considered a value-added logistics service (in scope). If the GTIN changes, this is considered contract manufacturing (out of scope).

Warehousing transactions involve the inbound instruction, dispatch notification and receipt notification (both inbound and outbound); warehousing notification, warehousing operation instruction; warehouse operations notification; and inventory request and report.
Figure 18: LIM warehousing
5.4 Integrated information exchange platforms

There exist a plethora of initiatives, both in research and in practice, for data exchange between stakeholders in the transport sector, some of which have been described in previous sections. These initiatives can be classified based on various criteria, such as scale of development, number of partners involved, modalities considered and so on.

In the literature there are few existing works which have attempted to classify these many initiatives. Such a classification would aid in further research.

During interactions with stakeholders in the transport sector during the research for this paper, it became clear to us that while many SMEs indeed participate in research projects and field pilots, the use of the latest technology and real-time data in their business processes remains limited, as Wilhemsson et al observed in 2014. Despite a continued push for better EU transport services by the European Commission, the situation has not changed much.

The transport sector has to evolve as an industry where initiatives for better transport practices are not only concentrated among big players but also small companies. Below is a list of initiatives which will foster increased cooperation between transport companies. This list was prepared based on meetings with transport SME representatives, information from industry seminars and desk research.

- **Navigate**[^107] is an online routing service hosted on the website of the port of Rotterdam which shippers in Europe can use to find an optimal multimodal route from their location to the port. The service also shows the (possible) freight forwards which can perform the shipment, their contact details, time taken for the shipment from origin to destination, and the CO2 emissions for the trip.

- **Nextlogic**[^108] is a cooperation between sea terminals, empty depots and barge operators with the objective of establishing an optimised, common and permanent solution for the IWT of containers to and from Rotterdam. Nextlogic provides a variety of services, such as integrated planning, a trusted information exchange solution, a performance dashboard, an information platform and a central planning tool.

- **Matchback**[^109] is a US-based company that is making its entry in the Netherlands and in IWT. Matchback combines import and export flows through algorithms in order to reduce empty routes. This can be done for all modalities.

- **SmartRail**[^110] is a project whose goal is to enhance the information sharing between various stakeholders involved in cargo transportation via railroad. In total it has 17 international partners from 11 countries. There are 3 tracks in the SmartRail project, namely dedicated service, connectivity of rail with other modes, and the reliability of and obstructions on the rail track. Track 1 aligns with creating trust and the correct environment for a sustainable modality shift towards rail, while Track 2 aligns with the data exchange pre-requisite of integrated transport. Track 3 aligns with enabling dynamic switching and an integrated network prerequisite of integrated transport.

- **Shareship**[^111] is a start-up which aims to reduce empty return trips of barges in Dutch waterways, as approximately 55% trips made by barges on IWT are empty trips. Through data sharing, ShareShip wants to reduce that amount and in the process reduce CO2 emissions and create more work and money for shippers.

[^107]: https://navigate.portofrotterdam.com
[^108]: www.nextlogic.nl
[^109]: www.matchbacksystems.com
[^110]: www.smartrail-project.eu
[^111]: www.shareship.nl
- **OpenTripModel**[^112] is an open source data model created for the easy online exchange of real-time logistics data between stakeholders in a supply chain. ICT and software providers can use the OpenTripModel to develop new logistics applications. Stakeholders can continue to use their own in-house IT system while simultaneously using OpenTripModel to exchange data among partners.

- **TeUbooker**[^113] is an online platform (launched in November 2016) to book unused space in barges, trains and road transport. An algorithm used by TeUbooker makes an optimised match between current market demand and individual operator capacity. After booking and during the transit of the load, the booker can monitor its cargo in real time via a personalised dashboard. The initial version of TeUbooker allows booking of unused space on vehicles coming to or going from the Maasvlakte area in Netherlands.

- **Project De Blauw Golf**[^114] is a joint project among the Dutch provinces of North and South Holland, Rijkswaterstaat and the port of Rotterdam to reduce congestion over Dutch IWWs. The real-time opening times of locks and bridges are made available to the skippers and LSPs which they can use to plan their routes and travel accordingly.

- **i-Share**[^115] is a system providing data access that has been developed for and by logistics companies in which the different parties have a pre-agreement which allows other parties to access their data. Mutual trust is a big concern for transport companies while sharing data about their business processes, demand and activities. To better address this area, in 2017 many private and public stakeholders in the transport sector came together to create the i-Share project. The goal of the project is to make common and mutually agreed-on policies for the identification, authentication and authorisation of logistics parties.

- **PortBase**[^116] was created by a merger between Rotterdam’s port infolink (est. 2002) and Amsterdam’s PortNET (est. 2000). PortBase’s port community system provides intelligent services for accessing information simply and efficiently between companies, private institutions and public institutions. Portbase is a non-profit organisation.

- **The Year of Multimodality** is an initiative of the European Commission, and has announced 2018 as the year of multimodality to further stress and work towards the need to reduce CO2 emissions, road congestion and promote modality shifts.

- **Rijkswaterstaat** is part of the Dutch Ministry of Infrastructure and the Environment. It is responsible for the design, construction, management and maintenance of main infrastructure facilities in the Netherlands. In Track 2 of the IDVV program (Impulse Dynamisch Verkeersmanagement Vaarwegen)[^117] logistics companies and knowledge institutes (supported and facilitated by the government) worked together on 13 innovative projects to improve the role of waterways in the Netherlands.

- **Lu (2014)**[^118] presents a list of EU- (and Dutch-) funded projects using smart IWW transportation. The results of these projects (e.g. SALOMO – Situational awareness for logistics multimodal operations in container supply chains and the network) will have a positive impact on building the necessary infrastructure for IWW. All national projects are/were funded by Dinalog (the Dutch Institute of Advanced Logistics) which corroborates the Dutch government’s support of IWW infrastructure development.

[^112]: www.opentripmodel.org
[^113]: www.teubooker.com
[^114]: www.blauwegolfverbindend.nl
[^115]: www.ishareworks.org
[^116]: www.portbase.com
[^117]: The IDVV program (2011-2013) was a 2-year program with 3 tracks, Track 1: Basic VTM services, Track 2: Single window for inland navigation and Track 3: logistics challenges. In total, 17 projects were initiated under the three tracks together.
[^118]: Lu (2014)
ALICE is another, more elaborate list of projects relating to sustainable intermodal transport.\textsuperscript{119}

\textsuperscript{119} ALICE (2015)
6. Obstacles and opportunities for increasing freight intermodality and ICT adoption on IWT

This chapter discusses how to categorise and analyse the different barriers to increasing freight intermodality, and how ICT can be implemented to improve the overall system performance-boosting intermodal transport chains to profit from the cost-effective, volume economies of scale and environmental-friendly advantages of the IWT mode. In the first and second sections we describe the barriers to freight intermodality and ICT adoption on the IWT. In the third section we discuss how ICT can be useful to overcome these barriers and be a key driver to promote the change. The last section present lessons learned from past completed projects conducted by project partners that could support our work on ST4W.

6.1 Barriers to increase freight intermodality

Due to congestion and environmental concerns intermodality is important for the efficient operation of transport and logistical systems that, at the same time, benefit from the related reduction of external costs. The following is a list of barriers for freight intermodality; these reflections are important for the work-team ST4W when analysing the organisational and technical framework of relevant transport and logistics systems.

- A highly fragmented market: The European transport sector is distinctively highly fragmented. Smaller freight forwarders have limited demand and therefore cannot achieve the economies of scales required to ship containers via alternative modalities except via road. Moreover, highly fragmented markets are characterised by the presence of consortia which can both be enablers and obstacles to intermodality. On the one hand enthusiastic and motivated companies in a consortium can trigger other smaller or less-motivated partners to switch to more sustainable transport practices. On the other hand, sceptical partners in a consortium can drag others down while transitioning to IWW or rail transport. Although there has been a trend of increasing scale in the sector and there are some large cooperatives and bigger fleet owners, most companies only own one or two barges. This means that the average market power in the sector is low, especially if compared to the shippers and LSPs. This harms the potential of the sector to profit from a potential modal shift from road to water for three reasons. The first reason is that shippers and LSPs are having trouble identifying partners with which to discuss such a modal shift; the market is so fragmented that they do not have a simple list of big IWW companies that can potentially perform transport for them. This leads to the second reason: there are simply not many parties that have a fleet large enough to offer a widespread service network with a high frequency. Shippers often need many calls with relatively small volumes and high flexibility that are best delivered by a transport operator with a large network. The third reason is more climate-related, because the many small companies on the market are often not wealthy enough to finance efforts to become more sustainable. This is a problem because road transport is currently working hard on more sustainable engines, making trucks more attractive as a green option. Another difficulty is that small companies have resources dedicated to innovation and change management. To overcome the fragmented state of the market, there is an ongoing trend of more cooperation between barge operators, with barge shipping lines and cooperatives slowly growing in number and T of cargo transported.

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120 Ecorys (2017)
121 Pojani, Stead (2015)
122 Ecorys (2017)
A low level of IT maturity: A low level of IT usage and maturity is a big obstacle for logistics SMEs in their transition to IWW and intermodality. For this transition the data requirements, business process integration requirements and T&T services might become necessary. Many companies which till now had been operating over one modality might only see this as a big investment and a big change with respect to IT needs. Previous researchers have observed that most companies neither have the required IT infrastructure nor have the funds to invest in a robust data integration solution and thus lag behind in pursuing intermodality.

Resistance to change: For some logistics companies, as explained above, shifting to IWW or rail transport is a big change which arouses resistance to changes in transport practices.

Lack of infrastructure: The unavailability/lack of appropriate physical infrastructure can be a major roadblock to IWW and intermodality. Physical infrastructure encompasses not only rail track and deep canals for rail connectivity and manoeuvrable waterways but also cranes, warehouses and cargo handling infrastructure. Some ports/terminals which have higher demands are more capable of boosting their infrastructure capabilities while others lag behind and might have to wait for government funds and initiatives. Some regions and countries are thus more advanced and ahead on the road towards cargo intermodality than others.

Lack of cooperation/trust: The lack of cooperation and trust (for data sharing) proves to be a major obstacle for the shift to IWW and cargo intermodality. Logistics companies are hesitant to share company data with other actors in the logistics chain which can hamper the shift to intermodality. Projects such as SELIS are specifically looking at topics and researching a solution strategy. Currently, what is observed in the logistics sector is that companies only share limited data with consortium partners. However, in a more federated and open logistics scenario, such a data policy might not be ideal.

Unreliability of/congestion at deep sea terminals: In 2017, research showed that 95% of 202 responding LSPs and shippers in the port of Rotterdam were troubled by the congestion in the port. Most of them suffered losses of several hundred thousand euros (Pieffers, 2017). For the IWW sector, this means extra congestion at barge terminals, where most of the equipment is moved to serve deep sea vessels when they arrive. Since the latter tend to arrive at unreliable times, the schedules for entire terminals are becoming less and less trustworthy. This means that barges can no longer count on fixed slots at terminals. This makes the IWW sector less reliable while shippers and LSPs see reliability as one of the most important factors for the choice of transport mode. The congestion is caused by a multitude of factors. First of all, deep sea vessels have seen a steep increase in scale during the past decade, meaning that more and more cargo is delivered to terminals per ship call. The handling capacity of terminals has not grown accordingly, so when a deep sea vessel arrives, there are few cranes to spare for barges. Together with the unreliable arrival times of deep sea vessels, this is leading to waiting times that are unacceptable for the tight schedules of shippers and LSPs. The latter is resulting in a reverse modal shift (from barges to trucks) in the port of Rotterdam area (Dijkhuizen, 2017).

The decreasing number of small barges: This is another barrier to increasing freight intermodality. IWT in NWE can make use of a dense and fine-meshed network of waterways. A big part of this network is only suitable for small ships with a maximum weight of 1,000
In the Netherlands the small waterways make up 1,600 kilometres out of a total of 5,000 total waterways. This means that 32% of the waterways is only suitable for small barges. While large IWWs often lead to relatively large inland terminals through which cargo is transported to its end destination by truck, small barges use the small waterways to reach small inland terminals closer to the end destination, or to the end destination itself. This means that small barges are the part of the IWT sector that has the most potential to compete with road transport. Unfortunately, the small barges are rapidly decreasing in number: from 1981 to 2003, almost 40% of smaller ships disappeared from the market and a more recent number show that the smallest class of barge is down to 5% of its fleet size from two decades ago. This is due to several reasons. First, small ships are usually very old, and the investments needed to keep a small barge in operation are often unprofitable. Second, barge owners are often unable to meet technical standards for IWW ships, as the small size of the vessel would cause the investment to be unprofitable or even technically infeasible. Third, the state of the small waterway network is responsible: regional authorities often overlook the fact that a channel or small river is used by barges. These authorities allow the mooring of houseboats and recreational ships, fail to maintain small locks and often forgo necessary dredging. This is making these waterways less and less accessible, leading to a failure of small barges to reach their destination and forcing their customers to use road transport. Fourth, small barges cannot be built in an economically feasible way; in the past 50 years, for instance, no new small barges have been built in the Netherlands. This means that competing with the denseness of road transport is becoming harder and harder for the IWW sector.

The lack of IT harmonisation in the transport sector with other modes of transport, LSPs and other actors such as (inland) terminals: Intermodality can benefit from a sharing of data between different actors in the supply chain; this allows each actor to optimise its transport operations because each actor knows the status of the operations in the rest of the supply chain. For example, a barge operator can be easily notified if there is some congestion in an inland terminal, giving it opportunities to change its own schedule of terminal calls or decrease the speed. When the IWW sector harmonises its IT systems and shares its data with the other actors in the supply chain, LSPs will find it simpler to choose a barge as a mode of transport. However, the IT harmonisation and data sharing is at the moment not fully utilised. Individual barge owners/operators sometimes think the sharing of data such as location, routes and estimated times of arrival are infringements on their privacy. Another problem is that the sector is not always using modern methods of data gathering, making it hard to share data. For instance, information sharing about such things as prices, orders, predictions about future cargo, the location of the cargo, planning and delays is still done per phone or e-mail by a large part of the sector. Although this seems to be a bad outlook, the sector does value the information that is available for them online. Hopefully, a step in the right direction can be made which will allow the sector to become an integrated part of more supply chains.

The popularity of just-in-time logistics (used in lean manufacturing): Many shippers aim to decrease the amount of stock they have to keep in storage, and LSPs cater to this by offering just-in-time delivery of products. This means that there will be many deliveries, but with

123 van Hassel (2015)
124 Algemeene Schippers Vereeniging (2012)
125 van Hassel (2015)
126 TNO (2017)
127 Promotie Binnenvaart Vlaanderen (2015)
relatively small amounts of cargo (most of the time small logistics units such as palletised freight or big bags). For such logistical models, road transport (truck or less-than-truckload) is ideal. Barges on the other hand usually carry very large batches and make only a couple of deliveries. Palletised freight, which is loaded directly in vehicles or bundled in containers, has to be consolidated for shipment by water. Effective logistics engineering is essential to ensure cargo consolidation, requiring an accurate synchronisation between operators and a collaborative approach demanding organisational and behavioural change from logistics professionals. In addition, IWW vehicles, materials and infrastructures are, in most cases, not really suited for pallet handling. Just-in-time logistics is also very vulnerable to faults in the delivery side of the supply chain. When a delivery is late, the customer can easily run out of stock. This is another minus for the use of barges for these kinds of shippers, because we mentioned earlier in this chapter that barge transport is becoming unreliable due to terminal congestion. However, even if the issues around congestion and unreliability were to be solved, barges would still have a hard time fulfilling the needs of a shipper using just-in-time logistics. This means that a modal shift to barges would force these shippers to keep more stock, and thus they would need more storage room. Another thing that is troubling for just-in-time logistics about barges is their speed. Even with a large amount of road congestion, trucks are still significantly faster than barges. This means extra effort to plan a just-in-time logistical network and for shippers with perishable goods it is one of the main negative aspects of IWT.

The (perceived) complexity of the organisation of intermodal transport, with regard to mono-modal transport (usually by truck): Mono-modality is the use of one mode of transport from origin to destination; this is usually simple to organise by contracting one transport organisation. Intermodal transport, however, involves more actors: usually the goods are transported along the longest distance by barge and delivered at an inland terminal. The last miles to the end destination are then covered by trucks, requiring transhipment operations at the inland terminal. This process needs to be coordinated, as the arrival of the barge has to be monitored, after which the trucks can pick up the cargo. If there should be stock left at the terminal, this must also be monitored. Another aspect of complexity in the market is found in the part of the supply chain between the shipper and the barge operator. Shippers can book directly with barge operators and road transport operators, increasing the necessary trade operations and administrative burden, but most use middle men for this. These middle men can be freight forwarders, LSPs, dispatchers or shipping agents, and they exist in all shapes and sizes. Sometimes, however, deep sea terminals or deep sea shipping lines also take on this role. To make things even less clear, some barge operators are vertically integrated and also offer terminal and other logistics services. This makes the market almost indecipherable for shippers without the relevant knowhow. All in all, it is easy to understand why the IWW market is perceived as complex by some shippers.

6.2 ICT adoption in the IWW sector

Over the past decades, the ICT adoption in freight transportation has been imperative, which is evident from the amount of scientific research and the EU initiatives in relation to ICT developments in multimodal transport.

128 Bookbindes, Dilts (2016)
129 HLN.be (2017)
130 CORDIS (2018)
Despite the ongoing IT solutions development (e.g. interoperability frameworks, cloud computing, IoT, blockchain) with regards to information sharing between the various supply chain actors, the adoption and implementation of ICT in the UK and EU level seems slow. A primary concern about ICT solutions adoption by IWT businesses and authorities is the relevance of a solution to the business, including the exemplified specification and description of the real benefits and values of such a solution. Stakeholders will never accept solutions that do not match the business user needs.

As information exchange is a primary concern for collaboration with other transportation modes such as road and rail, the adoption of innovative ICT on the IWW sector is indispensable to achieve ITS.

The following section details information exchange needs between IWW actors, while the next section provides a more thorough analysis of the barriers in IWT solutions deployment and their stakeholders’ buyout impediments.

**IT information needs in the IWT landscape**

Using the actor types defined in the previous section, we describe some important information exchanges between the IWW actors and the actors’ need for this type of information using as a baseline a common and relevant business case.

The waterway managers or port authority oversee maintaining the infrastructure and managing the traffic flows which is especially important in limited space areas such as near bridges or locks. In the day-to-day information exchange scenario in IWT, the information sharing between the waterway manager and the barge operator is based on a two-way communication; for example, the barge operator sends information about the vessel position and the type of cargo (e.g. dangerous goods), while the waterway manager informs the barge operator about the condition of the fairway (such as the water levels) which can be used to plan voyages more efficiently and securely.

<table>
<thead>
<tr>
<th>Information Sharing</th>
<th>Available transport services</th>
<th>Booking data</th>
<th>T&amp;T of cargo (ETA)</th>
<th>Compliance data</th>
<th>Traffic data</th>
</tr>
</thead>
<tbody>
<tr>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Freight forwarders</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Barge operators</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Authorities/ Waterway managers</td>
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<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 2: Information access needs in IWT

The table above shows the important basic types of information shared between the primary IWT actors, where the commonalities between shippers and freight forwarders regarding data requirements can be observed.

From the shipper’s perspective, finding and booking the most suitable IWT logistics service can be challenging. They usually need to directly contact individual operators via phone or e-mail which is time-consuming. In addition, having visibility of their shipments during the movement or information about the ETA can also be problematic. Although some companies use AIS for tracking vessels, there
are issues with accuracy, privacy and liability. Similarly, freight forwarders need access to services offered by transport companies, easy booking facilities, visibility and synchronisation capabilities. The key difference is that LSPs can combine these services into an integrated offering by selecting the best modality for a certain shipment at a certain time. Considering the complexity of the collaboration scenarios the freight forwarders handle daily, it is reasonable that they rely increasingly on advanced ICT systems and are therefore open to new technologies and ICT solutions.

Shippers are also relying on advanced ICT systems to better control their supply chains. However, their interest in IT technologies may be compromised depending on several factors, such as the size of the company, the complexity of integrating with external systems and the type of cargo transported. Small shippers are usually traditional companies with limited IT infrastructure, or they use old IT solutions which are difficult and expensive to customise.

On the other hand, both barge operators and waterway managers are more interested in traffic data. More specifically, barge operators need detailed traffic information to plan their voyages efficiently, while waterway managers need data on planned voyages of barges to plan traffic.

Barge operators aim at saving costs and time by reducing fuel consumption and waiting times in ports and terminals, and by increasing fleet utilisation by attracting additional payload from customers. Although some voyage data is available to the waterway managers through AIS, they lack access to the full voyage plan of the vessel which limits the possibility to accurately predict congestion.

Overall, barge operators are likely to find it more difficult to keep up with the latest ICT solutions mainly due to financial constraints, and therefore the other actors need to ensure their connectivity to the transport networks. Finally, waterway managers are relying mainly on paper-based communication due to the bureaucratic structure of their organisations. The abovementioned shared information requirements form the basis of the following consideration of ICT barriers.

**Barriers related to ICT adoption in the IWT sector**

ICT innovations in logistics for the IWT sector are not only a potential source of numerous benefits but they can also mean significant adoption challenges such as connectivity to on premise applications, potential outages or loss of control over IT resources.\(^{131}\)

ICT solutions supporting collaborative business models are considered an important way to remedy sub-optimal logistics and yield significant business benefits such as cost reduction and improved asset utilisation. However, they can bring significant challenges with regards to their adoption, such as trust; resources for exploring; and exploiting the collaborative practices, information confidentiality, willingness to share and collaborate, and unclear governance.\(^{132, 133}\)

The technology barrier dimensions expected to be confronted during ST4W are considered across the following axis:

- **Technology readiness, organisational context and competence:** Current use and level of interest of the different technologies among the IWT stakeholders/users of ICT solutions. This also includes organisational factors that affect the adoption of the ST4W solutions and the required levels of skills to deploy and operate these solutions.

\(^{131}\) Marston, Li et al (2011)  
\(^{132}\) Dyer, Singh (1998)  
\(^{133}\) Villena, Revilla et al (2011)
**Business and technology integration and change management:** Expected organisational barriers for the implementation of the ST4W solution, mitigated with organisational and governance enablers. Change management deals with the natural resistance of every organisation to changes, and certainly technology innovation requires organisational, process and technology changes.

**Technology integration and security concerns:** Expected technological barriers with the implementation of the ST4W solutions. These will appear as new systems are deployed which deal with data and information exchanges, telecommunication services and sensors, workflow, and collaboration systems introduction, reflecting process changes and cloud technologies which defy the traditional long-used in-house data room concept.

**Organisational aspects and characteristics:** Where the industry sector, the size and culture of the company and the access to financial and human resources are considered important.

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**Technology readiness and organisational competence**

Technology readiness depends on the skills-related operational barriers, referring to problems related to the lack of trained/skilled personnel resources. Barge operators are usually SMEs of limited size with relatively flat structures and without internal IT expertise and trained staff. During the fieldwork analysis, it became apparent that certain actors in the supply chain remain attached to long-lasting relationships with their clients and use traditional communication work methods.

It should be noted that the lack of internal skills and training within companies has been already identified by many as an important adoption influencer. Further analyses about the effect of this factor conclude that it should depend on the type of product/solution considered – for example, the perceived technology competency is an important factor for IaaS solutions and not a determining factor for PaaS and SaaS solutions.

Considering the lack of modernisation of their day-to-day operations, particularly in small transport companies, the need for employing qualified personnel is limited. However, even though some SMEs have stated their interest in implementing ICT solutions, the absence of ICT specialists and a skilled personnel shortage to operate new applications were considered limiting factors.

Additionally, more traditional companies consider employee training and educational activities costly and usually are not aware of government policies which result in reluctance to change or learn new technologies.

**Business and technology integration**

The business concerns for technology integration and a source for potential barriers are usually eminent when technology does not match the business user needs, and therefore these barriers do not receive strong support from the higher management of businesses. A literature review of the main technological barriers linked to the implementation of ICT highlights the main barriers identified with regards to the implementation of new technologies that are the highest in relevance and priority. The most important barriers are:

- Governance, data ownership, privacy and confidentiality issues

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134 Kuan, Chau (2001)
135 Tornatzky, Fleischer (1990)
136 Oliveira, Martins (2011)
137 Kaisler, Armour, Espinosa, Money (2013)
138 Schoenherr, Speier-Pero (2015)
139 Chowdary (2016)
Change management issues (resistance to change)

Barriers with respect to governance and ownership of information, including data confidentiality and data protection

Further, change management is an important aspect of technology solutions adoption and should be given sufficient attention, as it is one of the most pressing issues. This is confirmed by a SELIS stakeholders’ survey, where the responders’ qualitative answers pinpointed the resistance to change as the main barrier for implementation, highlighting the necessity of developing highly compelling solutions with the simplest adoption/integration capabilities.

Technology integration and security concerns

In this section an analysis of ICT categories is provided that describes the importance and relevance of ICT technologies to the implementation of IWT collaborative and decision support solutions based on a recent analysis performed in SELIS:

- **IT systems enabling the internal and external data management, gathering, processing and exchanges**: It is considered a high-interest area and of great importance where data is used for analytics processing and in strategy planning, as well as in optimising collaboration processes. Currently, in larger operators, systems are in place for gathering, analysing and reporting information and for performing internal data analytics. However, although the reporting of and processing on internal data is already well-established, external data gathering and processing as well as the reporting of external data are still not optimal, providing a market opportunity to deliver a useful proposition. Therefore, an interesting IWT solution should provide stakeholders with the ability to integrate data arriving from collaborative processes, improving their current practice on data gathering/integration from external processes to generate 360° views that include both internal and external data.

- **Telecommunication services and sensors**: Regarding the collection of data through sensors and telecommunication devices, this is considered as important, especially with the future vision of the IoT, as it increases visibility and lets the tracking, tracing and monitoring of the supply chain improve by collecting temperature data, barge status, fuel consumption and emissions information. The focus is more on using existing telecom options for communication, including mobile and satellite networks, and as mobility initiatives are progressing. The satellite solutions are more relevant to connections where the other two options are not eligible, mainly in maritime connectivity, presenting an opportunity for the implementation of these technological components. Today, IoT and telecommunication services seem to be attracting significant interest.

- **Systems for cross-organisational collaboration using information exchange**: Cross-organisational collaboration ICT solutions support information exchanges for different processes across organisations where businesses are expressing interest in acquiring, deploying and using them to set up B2B and business-to-administration collaboration, including end-to-end delivery with full supply chain visibility, synchronmodality, reverse logistics and sourcing solutions. In general ICT barriers include the lack of systematic support (i.e. analytics) in business areas that affect supply chain strategies and require advanced decision support, analytics trip/route consolidation and collaborative planning.

- **Cloud technologies, data management and analytics systems, and process improvement solutions**: This includes a wide palette of ICT and applications for the supply chain using customisation to support IWT requirements, such as simulation for business models testing and planning, green logistics, reporting and environmental key performance indicators.

140 http://www.selisproject.eu/
141 SELIS Deliverable D1.3, Capacity Building Requirements
master data management and standards support for information exchange, contract management, monitoring and SLAs, big data analytics, cloud technologies, configuration and deployment, workflow integration and business/IT reorganisation to digitise and transform inefficient processes to deliver productivity gains.

For cloud technologies, the most important barriers are again linked to the security concerns, data ownership and privacy, whereas for the big data solutions, the most important barrier is linked to the lack of skills. The quantitative results of the survey were further validated by the qualitative information that was gathered and that shows that data security issues are some of the main barriers for a transition to a collaborative cloud platform.

Some of the main problems with the use of different technologies observed in logistics stakeholders mean that attention should be paid to the following individual issues:

- Accurate information about end-to-end supply chain processes (e.g. deliveries) is not readily available
- Companies have difficulties with exchanging data, reporting and information with their suppliers and customers
- Risks or delays in the supply chain are not properly reflected
- There are problems with gathering data from logistics operations
- Companies have difficulties exchanging data, reporting and information with the public sector

Potential barriers with regards to the implementation of new telecommunication services and sensors concern:

- Cost of solutions; hence, ST4W should focus on solutions that reduce the cost to access and use the right technologies for exchanging information for collaboration and analytics. A potential barrier is that companies have a lack of internal knowledge to assess the cost-benefits-viability return on investment of IT solutions. It has been observed that companies, especially SMEs, have problems performing cost-benefit analysis for the implementation of the new collaborative solutions and are afraid of the loss of the competitive advantage by helping competitors. Furthermore, this result is added to the often-unclear business case or the demonstrated ICT solution value. This issue can be even more pressing when an exact IT solution (i.e. a product or a service) has not been fully defined, making it more difficult to assess gained values vs. costs. On the other hand, current cloud computing services are often not cost-effective for larger enterprises, especially those that have achieved best-of-breed efficiencies from their computing operations.
- Communication facilities for remote areas are one of the problems in transport and logistics. To deal with this problem, possible solutions deploy AIS/ASM (automatic identification system-application specific message) via low earth orbit satellites to transmit data between ship and shore to facilitate information visibility in future maritime transport systems. This is relevant for ships without advanced satellite terminals in remote areas where terrestrial infrastructure is not available. The rationale is that there is an increasing need to have online monitoring information, also from ships without satellite communication, to integrate this information into supply chains and other systems. In these cases, the AIS can be a low-cost and general alternative to ordinary satellite communications. AIS can be used for communication in remote areas, and when the ships are near the shore, they can use low-cost terrestrial communications systems.
Organisational aspects and characteristics

Company characteristics such as company size and ICT maturity level has been found to be an important factor to be accounted for in technology adoption.

The size of the company plays a significant role in the adoption or implementation of ICT solutions. On an international level, it is obvious that SMEs are more likely to have difficulties in the implementation of ICT due to financial and human resources constraints. In contrast to the large companies that have the economic and technical capabilities to develop bespoke platforms based on their business needs, SMEs cannot afford the investment costs of IT solutions which eventually lead them to use traditional communication and processing systems with their business partners. Another restricting parameter in the ICT implementation is the fear of the need to frequently update the technologies used which results in increasing maintenance costs.

The size of the organisation also relates to the existing IT infrastructure and the adoption of cloud services. Indeed, experience shows that cloud computing makes eminent sense for SMEs since the prices and the SLAs from the leading cloud providers are far better than what most SMEs can realize with their modest investment levels; in addition, since cloud computing needs no upfront investment, this allows cash-strapped SMEs more flexibility with the use of their capital. As regards the nature of organisations, clear business cases are very relevant and have to take into account the organisation characteristics, translating created values to the exact situation concerning the setup (whether this is a shipper or an administration).

Hence, an important barrier for the introduction of novel analytics, collaborations etc. in the business domain is the lack of convincing business models so that top-level management is engaged and supports technology-driven initiatives; for example, the problem of disproportionate cost and benefits can be an important barrier for adoption. An unclear business case or unclear value in the use of an ICT is an adoption barrier, and prioritisation between must have/should have/nice-to-have features that the stakeholders within an organisation ask for must be clearly defined and well-documented.

6.3 Looking ahead to smart IWT

In this section we look at how to overcome barriers to smart transportation in IWWs. In future, researchers and practitioners should focus their efforts on these points.

- The creation of a smart logistics ecosystem is critical for a transition to changes in European transport practices. In other words, if one logistics company decides to change its way of working or use a specific modality more than others (e.g. the greater use of IWW as compared to trucks), chances are that it would not be successful in achieving its goals until and unless its business environment (partners, contractors, employees) together initiate and pursue a change in their respective work processes.

- In most logistics transport SMEs, planning and cost calculations are made manually by a planner who has the expertise and the skills. The use of little-to-no IT tools makes these planners irreplaceable. However, most SMEs would like to use software solutions for capacity planning, route planning and transportation costs. Use of these types of software will trigger better demand and capacity matching, just like the use of standards such as EDI has transformed the transportation industry (by removing all paper business documents with digital business documents).

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142 Marston, Li et al (2011)
143 Hofman (2014)
Furthermore, in a distributed system where different stakeholders such as inland terminals, shippers, barge operators, cargo handling companies and warehouses have access to this data, this would lead to better-coordinated supply chains.\textsuperscript{144} The need for such an integrated and distributed platform has been voiced by many researchers from the transportation domain. For example, Giannopoulos\textsuperscript{145} stresses the need for logistics information systems to be “Integrated, Intermodal, Internet-based and Intelligent”. Similar ideas have been voiced by Pfoser et al \textsuperscript{146} and Singh.\textsuperscript{147} Such platforms can further contribute to a logistics ecosystem by functioning as an Internet e-marketplace. On this e-marketplace, LSP can bid for cargo to be transported. Using such options LSP can have the freedom to compare and choose different modalities and routes.

For more and more logistics SMEs to use IWWs, it is important the impetus from government is maintained, i.e. that respective national governments and the EU continue to encourage research projects and initiatives. Also, the role of advertising and media campaigns (aimed at promoting IWT) should not be ignored.

How ICT can promise opportunities to improve the overall performance

In this section we discuss how ICT technologies can prove useful to overcome some of the barriers to intermodality. For the sake of coherence we discuss these in the same order as mentioned in the introduction to Chapter 6.

- A highly fragmented transport sector: ICT tools can facilitate the supply and demand consolidations for different actors in a region or providing transportation services on the same transport corridor. Such a consolidation policy will enable sharing of infrastructure behind LSP, thereby leading to more sustainable transportation. A good example of this case has been the TEU booker application mentioned previously. This application allows shippers to use empty space on barges, thereby providing an open and cheap solution.

- The low level of IT maturity in SME logistics companies needs to be addressed by researchers to enable a transition towards intermodality in IWW. The usage of cloud applications (such as aPaaS) could provide a solution to this problem. By using aPaaS service logistics companies can benefit from state-of-the-art service without investing in the ownership costs and maintenance costs. Relevant examples (mentioned in Section 5.4) are Navigate and Portbase. These services provide routing, partner data and real-time event information to clients.

- Resistance to change for intermodality and synchromodal transport is a big barrier for logistics companies. Planners in logistics companies have a way of working which they have been performing for years. Any new (and/or additional) activity is seen by them as extra workload which complicates their work. In such cases the use of a serious game (such as Synchromania) can be beneficial to change the mind-set of the planners. By playing such a game planners are made aware of the benefits of optimal planning and the use of real-time (contextual) data.

- The congestions in IWT and lesser flux of cargo (as compared to road transport) can be seen by some LSPs as a roadblock. Collecting and broadcasting real-time data over IWW infrastructures is one way of addressing this barrier. Projects such as Blauw Golf in the Netherlands are aiming to reduce such barriers by providing real-time data about bridge opening times, open berths and lock opening times to the skippers and thus to LSPs. When this information is available, it leads to better route (and modality) planning, thereby reducing congestions in waterways.

\textsuperscript{144} Pecher (2016)
\textsuperscript{145} Giannopoulos (2009)
\textsuperscript{146} Pfoser (2017)
\textsuperscript{147} Singh (2014)
The lack of IT harmonisation between parties in a transport chain can be addressed by the use of integration platforms. These integration platforms should allow different parties to connect to them, share data and use services. Such platforms will allow different parties to collaborate. During interviews with logistics company representatives, it was discovered that all parties use their own IT systems for logistics operations, giving rise to interoperability and integration problems.

In a much-regarded report of November 2015 (A turning point: The potential role of ICT innovations in ports and logistics), The Economist Intelligence Unit with DP World identified 5 key ICT innovations for ports and logistics firms that would change the game in the coming years:

1. **Robotics and automation**

Firms automate their logistics chains for two main reasons: it replaces labour, which is becoming expensive while the cost of technology is lowering. Robots operate quicker, in the context of pressure, speed and productivity, especially in the e-business sector. Eventually, robots will be connected to software and will be able immediately react to orders and changes.

2. **Autonomous vehicles**

Autonomous vehicles are a category of robot still under development and include driverless trucks and cars, drone planes and drone ships. As with robots, they avoid the high cost of labour, can work full time and reduce the liability of firms (in the case of human error).

3. **The IoT and big data analytics**

Objects in the supply chain are more and more connected to a network through sensors such as RFID, and they send and receive data. This generates a considerable amount of data that can be analysed in order to improve efficiency, remove bottlenecks etc.

4. **Simulation and virtual reality**

Simulation will be more and more used in logistics in order to model and improve the supply chain, especially in the context of growing automation.

5. **Cybersecurity**

The extent of ICT in supply chains makes them more vulnerable to bugs and cyberattacks. As a consequence, cybersecurity will play a major role in the supply chain.

These innovations apply not only to ports but also the entire supply chain, the ultimate outcome of which is the “physical Internet”.

**Concept and benefits of the physical Internet**

The overall performance in the system will be improved by the combination of all these ICT innovations. The connection of automated objects and devices, together with global data sharing, will enable:

- A global transparency of data and interconnectivity of systems
- A centralised management of data
- The application of artificial intelligence

The outcome of this is the physical Internet. The concept is to connect and synchronise all logistics networks to create a collaborative and robust physical network of networks, capable of continually optimizing the shipment of “encapsulated” goods of many types and sizes.

This concept is still under development, but the basic idea of it is that ICT could lead to an ultimate optimisation of the supply chain by central management of all the resources, with interoperable logistics units, and letting an artificial intelligence arbitrate the best solutions for transport and warehousing in real time, thanks to the interconnectivity and automation of systems.

A roadmap to the physical Internet has been designed by the European Technology Platform ALICE, in order to implement it within 2050.149

6.4 Lessons from past completed projects

Projects are complex undertakings with a lot of challenges. During the execution of project a lot of things can go well or go badly. When project partners perform a meaningful reflection about these experiences, knowledge is generated. Knowledge is defined as a “fluid mix of framed experiences, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded in not only documents and repositories, but also in organisational routines, practices, processes and norms”. Part of successful project management is routinely identifying, capturing, analysing and disseminating lessons learned. Learning from previous project experiences can help achieve economies of learning, and reduce the probabilities of miscommunication, rework and mistakes with the inherent financial and performance-negative effects. In this section ST4W project partners reflections on experiences that happened in similar past completed projects are described, making this information available for others to learn from. We concentrate on lessons learned with a direct impact on the strategical execution of ST4W, not on the administrative organisation of the project.

The ST4W-learned lessons which partners consider are relevant for the technical development of ST4W solutions are as follows:

- **Industry conformism**: Working on adaptation and specification of potentially valuable electronic data-based tools requires a vast effort in getting the actors aligned. This requires a careful stepwise and foremost iterative and flexible process, starting with very simple technology solutions and continuous interaction with the industry to adapt and get it accepted. However, this takes time as the industry has its own pace and interests. There is a need to have continuous insight based on connected sources of data (direct system integration). Due to legacy systems, connections are sometimes hard to make.

- **Openness**: Adoption of open standards as an underlying design is imperative, with the recognition that ICT systems across the supply/transport chain are currently represented by closed and proprietary approaches, proprietary information exchanges and data management standards that collectively hinder collaboration.

- **Unified communications**: A unified information exchange mechanism can facilitate end-to-end awareness of all supply chain events, as well as forge trust and increase reliability among the involved parties, concurrently increasing customer satisfaction and decreasing stock levels along with the respective operational costs.

149 http://www.etp-logistics.eu/
150 Davenport, Prusak (1998)
- **Accurate predictions**: Data analytics and machine learning methods can derive patterns on historical data and develop a predictive model that can standardise how transport mode reliability is measured as a starting point for interaction and gaining trust between supply chain actors. To become a standard and to become widely used in the inland transport industry for better decision making and better operational transport planning and execution, the tool must be made generically applicable.

- **Data quality**: Without a data normalisation mechanism, human errors occur and decrease the operational efficiency, with considerable man-effort investment.

- **Accurate ETA predictions**: ETA estimations are a key element both for proper planning as well as setting up targeted mitigation strategies in case of anticipated delays. Planning based on accurate predictions is directly translated to the improved utilisation of resources.

- **IT infrastructure**: New IT solutions are often hindered by the lack of or an obsolete IT infrastructure that is hard to maintain and to support the necessary interoperability. Most of the cloud-based solutions rely on the availability of high bandwidth and reliable Internet that is frequently unavailable in most of the waterway transport.

- **Tool languages**: Tools have to be developed in multiple languages (German, Dutch, French, etc.), as not all ship owners have a sufficient command of the English language.

- **Automation level**: The level of automation differs among the IWT companies. For example, some barge operators have no computer on board the vessel or some have computers with old versions of Windows.

- **Close reality**: Benefits of the software have to be evident for the user; otherwise this will result in a one-off usage. Having a user group for the exchange of experiences and providing feedback on the IT tool(s) can be very advantageous for the (continuous) improvement of the tool(s).

- **Legislation**: A legislative initiative to push for standardisation and openness of the data is imperative to enable and accelerate a unified solution capable of serving all the industry requirements and needs.

- **Solid business plan**: There has to be a clear business plan behind the adoption of new IT solutions, to ensure that the introduced technical innovations will materialise into specific business and economic benefits.
7. Conclusions

IWT is a very complex system characterised by multiple stakeholders and sensitive but indispensable interfaces with other transportation modes. Although it has strong dependencies on weather conditions (water levels) and has relatively slow transportation times, IWT offers unbeatable advantages such as low emissions, free capacities and high cargo security. However, IWT potentialities remain relatively unexploited with a strong predominance in few countries and on bulk cargo. Transporting palletised goods through the IWT still offers great potential to develop and grant more access to SMEs. An emergence of this new market could lead to new business models on the IWT and/or optimisation of the actual work schema. The ST4W strategy to reach this goal is the empowerment of end-to-end seamless visibility of transport data through a hierarchical tracking solution to introduce innovative IT solutions on the IWT.

In order to develop widely acceptable tools it is imperative to study last trends and new enablers dictating new developments of IT in IWT. We understand organisational trends as a manifestation of new technological enablers unlocking an existing company’s needs. We identified that ST4W tools promise solutions for more synchronomodal, cooperative and harmonised supply chains through cloud computing, telematics and IoT enablers. It would be of great interest for future developments to explore the milestones ST4W could reach to implement augmented reality on the IWT.

Digitalisation of the IWT is essential for the stronger integration of inland navigation into digitally controlled logistics chains. In this study we analysed current ongoing and closed EU projects on this theme to identify the most recent technologies that are being currently deployed in Europe and possible interfaces between these new products/technologies and the ones to be developed on ST4W. As a result, the Rhine-Alpine, RIS COMEX, Aeolix, SELIS, ECOLOGISTICS, e-Freight, GET Service and RISING projects will be an important reference for ST4W and form a high interest for interactions between solutions and work teams. Through this research, the ST4W project team gained important knowledge about the management of IWT.

In order to extend and exchange project-team expertise on the technical framework of IWT, a comprehensive overview of the highest level of general development of IT used by IWW stakeholders was performed for the management of: 1. Freight resources 2. Terminal and port information 3. Freight and fleet tracking 4. Integrated exchange platforms. Nevertheless these different technologies are working in silos, to the detriment of end-to-end seamless visibility. Thus, interoperability between the different systems and devices should be secured by using common standards in order to increase trans-modal visibility. This will be a main challenge for ST4W project work.

What is essential for the successful execution of projects is the early identification of barriers that might affect our project or its outcomes, as resistance is always experienced when change is first promoted. On the one hand, the project could encounter resistance from stakeholders for the modal shift to intermodal transport, and on the other hand resistance to adapt new IT solutions could occur. Thus, reflections on how these barriers could be addressed were conscientiously made. Thus, ST4W project partners reflected on experiences from past completed projects which could have a direct impact on the strategical execution of ST4W.
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