Green Inland Ports

Study on Enabling Sustainable Management and Development of inland ports

D3.5 Inventory of good practices at EU and international level
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Contents

Summary 4

List of abbreviations 5

1.0 Introduction 8

2.0 Good practices in inland ports 11

2.1 Geographical reach of identified good practices 11

2.2 Categories of identified digital tools 12

3.0 Good practices in the European Union 18

3.1 Port of Sevilla – Posidonia Operations 18

3.2 Port of Györ-Gönyü – Information exchange platform 20

3.3 Port of Strasbourg – VIGIE 22

3.4 Port of Trier – DigiTest Optimal Character Recognition 26

3.5 Ports of Rhône – Ci5 Port Community System 28

3.6 Rhine Ports – RiverPorts Planning and Information System 30

3.7 HAROPA Ports – Passage Plan 33

3.8 Port of Antwerp – Qless vehicle booking system 35

3.9 Port of Antwerp – Barge Trafic System 37

3.10 Port of Antwerp – Antwerp Port Information & Control Assistant (APICA) 39

4.0 Good practices on international level 44

4.1 Port of Trois-Rivières – Traffic XHub 44

4.2 Port of Montreal – Trucking PORTal 46

4.3 Port of Montreal – GALILEO Automated workforce management 48

4.4 Port of Haiphong – Smart Gate 50

4.5 Port of Haiphong – ePORT 51

4.6 Pangaon Inland Container Terminal – Online Vessel Billing System 53

4.7 Port of Wuhu – Blockchain document management system 55

4.8 Port of Shanghai – Yangtze River intermodal platform....57
4.9 Port of Hefei – 5G technology for autonomous vehicles and cranes control....60
4.10 Port of London – Maritime Emissions Portal....62
4.11 Port of Barranquilla – PEL Puerto en Linea....64
4.12 Port Governance Agency of Serbia – PEP and Invoicing....66

5.0 Conclusions....70
5.1 Operational and efficiency gains....70
5.2 Environmental benefits....70
5.3 Common elements and key takeaways....70
5.4 Main messages....71

6.0 References....73
6.1 Publications....73
6.2 Internet sources....73
6.3 Other sources....75

Summary

This report presents a comprehensive overview of good practices in inland port digitalisation, drawing insights from 22 case studies sourced from both European Union (EU) and international contexts. Through a thorough approach of desk research and stakeholder interviews, the report showcases innovative digital tools and technologies deployed by inland ports worldwide.

Desk research formed the cornerstone of the investigative process, involving an extensive review of literature, reports, and case studies, complemented by online resources dedicated to inland port digitalisation. This methodological approach facilitated the identification of potential case studies and provided background information on the digital tools and technologies under scrutiny.

Interviews were conducted with representatives from a range of inland ports where contact was established with port management. These interviews shed a light on the implementation process, challenges encountered, highlighted key learnings, and explained the environmental ramifications of digitalisation.

The combination of these efforts resulted in the curation of 22 case studies, comprising 10 examples from EU inland ports and 12 internally, for example the United Kingdom, Serbia, North America, Asia, and South America. A range of digital tools, from online invoicing portals and electronic reporting platforms to berth planning systems and port community systems - these case studies capture a breadth of innovative approaches and different strategies.

This report serves not only as an input to the Digitalisation Masterplan (as the major output of Task 3) and to Task 4, but also as an insight for inland ports embarking on their digitalisation process or seeking to further improve their existing digital initiatives. Through the examination of successful strategies and solutions, this report contributes to the ongoing advancement of sustainable and efficient practices within the global network of inland ports. The respective results of this task and deliverable have started to be presented to the relevant stakeholders and events organised by the GRIP Consortium in Task 5.

List of abbreviations

AI	Artificial Intelligence
AIS	Automatic Identification System
APICA	Antwerp Port Information and Control Assistant
BTS	Barge Traffic System
CNR	Compagnie Nationale du Rhône
CO	Customs Office
CPA	Chittagong Port Authority
DO	Delivery Order
EA	Environmental Authority
EDI	Electronic Data Interchange
EGD	European Green Deal
EMS	Environmental Management System
EMT	Environmental Management Tools
EPM	Environmental Performance Measurement
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FF	Freight Forwarder
GOS	Gate Operating System
GPS	Global Positioning System
HAROPA	Le Havre, Rouen, Paris
HMO	Harbour Master's Office
ICT	Inland Container Terminal
ID	Identification document
IoT	Internet of Things
IT	Information Technology
IWT	Inland waterway transport
KPI	Key Point Indicators
LTC	Land Transport Companies
MEA	Maritime Employers Association
MEP	Maritime Emissions Portal
MPA	Montreal Port Authority
NDRC	National Development and Reform Commission
NOx	Nitrogen oxides
OCR	Optical Character Recognition
OF	Outbound Full
PA	Port Authority
PAMS	Port Asset Management System
PAS	Port Autonome de Strasbourg
PCS	Port Communication Systems
PEL	Puerto en Linea
PGA	Port Governance Agency

PLA	Port of London Authority
PM	Particulate Matters
PP	Port Police
QC	Quay Crane
RFID	Radio Frequency Identification
RIS	River Information Services
RMG	Rail Mounted Gantry (Crane)
RPIS	Rhine Ports Planning and Information System
RTG	Rubber Tyred Gantry (Crane)
RTLS	Real-Time Location System
SA	Ship Agent
SaaS	Software as a Service
SC	Shipping Company
SIPG	Shanghai International Port Group
SOx	Sulphur oxides
TEN-T	Trans-European Transport Network
TO	Terminal Operator
TOS	Terminal Operating System, Terminal Planning and Operating System
VBS	Vehicle Booking System
VGM	Verified Gross Mass
VIMC	Vietnam Maritime Corporation
VTMS	Vessel Traffic Management System
VTS	Vessel Traffic Services

01

Introduction

1.0 Introduction

Inland ports have a very important position in the global trade and supply chains. They represent important nodes of the overall transport network, especially in the European Union, where they play an indispensable role of engines of economic growth not just of their immediate hinterland, but frequently of their host countries as a whole. Very much like seaports, inland ports have gone through an evolutionary development through history, from being merely sites for the transfer of goods from ship to shore and vice-versa, to multidimensional economic hubs hosting the widest possible myriad of activities, stakeholders, businesses and industry branches. This ongoing evolution, from the 1st generation of ports to the 5th[1] and 6th[2] generation of ports, reflects the dynamic environment in which inland ports operate and the need for their quest for constant improvement of their efficiency and overall sustainability.

Inland ports are recognised as an essential part of the EU transport infrastructure forming the core Trans-European Transport Network (TEN-T). As such, inland ports have a high importance for the EU connectivity, mobility, economy and its regions. Inland ports enable the cargo related operations for at least three different modes of transport – road, rail and inland waterways. When they are located at river estuaries or in the areas allowing seagoing vessels to use inland waterways, inland ports extend their activities towards maritime transportation as well. For this reason, and due to the fact that inland ports provide infrastructure and other facilities enabling the transfer from less environmentally friendly modes of transport (e.g. road transport) to more environmentally friendly ones, they have an indispensable role in the European Green Deal's[3] (EGD) ultimate goal to bring down the transport related emissions by 90% until 2050. Apart from EGD, the importance of using more environmentally friendly modes of transport is also recognised by other policy documents, such as, *inter alia*, the Sustainable and Smart Mobility Strategy[4] and the NAIADES III action plan.[5]

The Sustainable and Smart Mobility Strategy, for example, acknowledged the significant potential of inland ports to establish themselves as zero-emission nodes, whereas such nodes would not be just transport nodes, but also hubs for sustainable mobility and industry, clean energy and the development of circular economy. This forces ports to draft a completely new agenda towards the implementation of new, environmentally friendly and sustainable solutions. These solutions must include energy efficiency, environmental strategies and monitoring tools that are needed to support the transition to renewable energy and zero-emissions operations.

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[1] Karaś, A. (2020). Smart Port as a Key to the Future Development of Modern Ports, *The International Journal on Marine Navigation and Safety of Sea Transportation*, 14:10. Available: http://dx.doi.org/10.12716/1001.14.01.01

[2] Kaliszewski A., (2018). Porty piątej oraz szóstej generacji (5GP, 6GP) -ewolucja ekonomicznej i społecznej roli portów, *Studia i Materiały Instytutu Transportu i Handlu Morskiego,* 2018

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0640

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0324

In order to set the stage for inland ports to comply with EGD goals, the European Commission has launched the Study in Enabling Sustainable Management and Development of Inland Ports (a.k.a. Green Inland Ports Study). The Study aims to support European inland ports to become zero-emission, sustainable hubs connecting Europe. The Study assesses the environmental impact of ports on their surroundings, looks at the role of digitalisation in becoming more sustainable and identifies opportunities to adopt inland waterway transport for urban mobility and short-distance transport.

One of the solutions that can lead inland ports to significantly contribute to the targeted reduction of transport related emissions is digitalisation. First, digitalisation is all about the streamlining of port processes, increased efficiency and productivity, and optimisation of movements in ports. These movements are typically related to the movement of vessels in ports, cranes, cargo handling equipment, trucks and trains. Optimisation of such movements directly leads to reduced energy consumption and therefore lower emissions even in the case where such movable port assets use fossil fuels. Second, digitalisation is an indispensable pillar of automation. Automated cargo handling equipment, apart from performing their movements along optimised routes, are more and more powered by alternative fuels, primarily electricity.

In this view, Task 3 delves deeper into the digitalisation of inland ports as one of the solutions to increase the efficiency and environmental sustainability of inland ports. The main objective of the Task 3 is to assess the potential of digitalisation for the greening of port operations, for ensuring multimodality and for facilitating sustainable development of inland ports. Findings of the Task 3 will be clustered in the major output of the Task, which is the Digitalisation Masterplan for inland ports and terminals supporting the wide-scale implementation of digitalisation in inland ports.

Deliverable 3.5 describes the work carried out within the framework of Sub-task 3.5 Inventory of good practices at EU and international level. It contains 22 cases of inland port digitalisation with a specific focus on the benefits in terms of efficiency and environmental impact of applied digital tools. Out of 22 cases, 10 were identified in European Union, whereas the remaining 12 are encountered globally.

The main objective of this sub-task is to provide an overview of the existing digital tools and technologies designed for the use in inland ports and which have (or have the potential to) improved the overall operational efficiency as well as the environmental performance of inland ports. The results of this deliverable will provide direct inputs for the Sub-task 3.6 (Digitalisation Masterplan), as well as the necessary inputs for the Task 4 (ESMS and pilot implementation of ESMS in selected inland ports) of the Study.

The respective results of this task and deliverable have started to be presented to the relevant stakeholders and events organised by the GRIP Consortium in Task 5.

02

Good practices in inland ports

2.0 Good practices in inland ports

2.1 Geographical reach of identified good practices

Following the requirements of the Terms of Reference, the Study team aimed at identifying minimum 20 good practices in inland port digitalisation, whereas 10 such practices should be located within the European Union, while the remaining ones were to be identified globally. The main criteria for the selection of good practices were positive economic, efficiency or operational impact, as well as contribution to the reduction of the environmental footprint of ports.

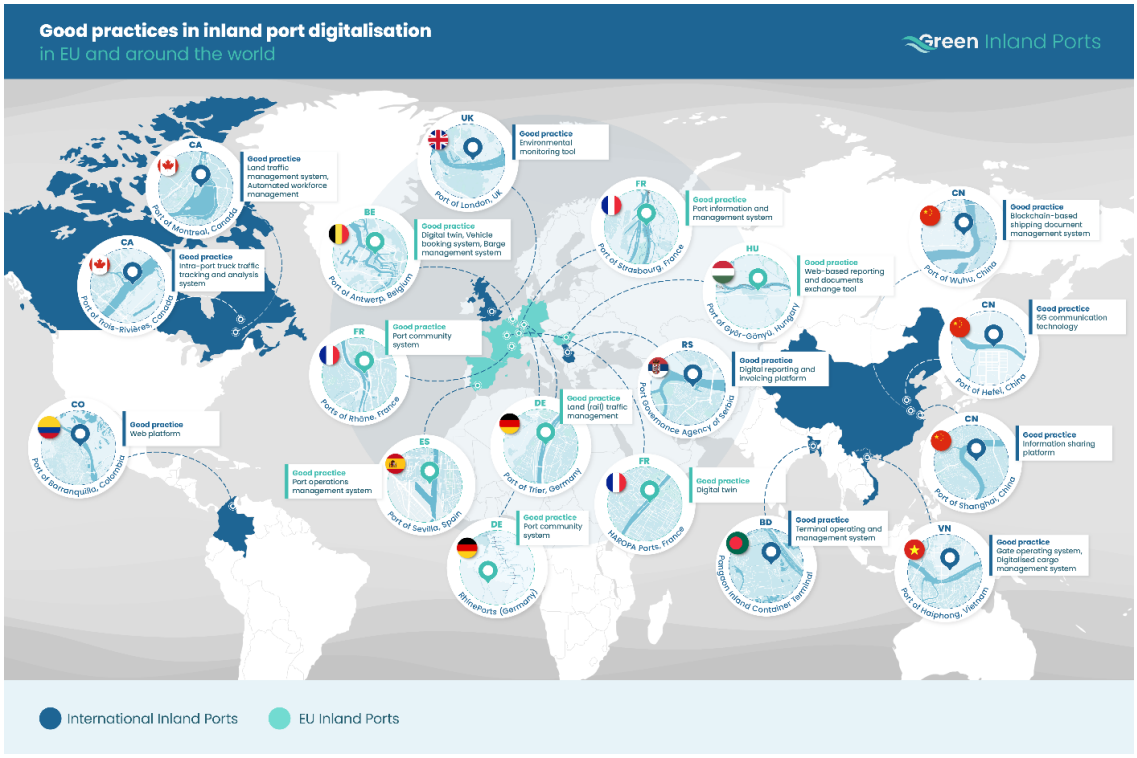
Combining the methods of interviewing the relevant inland ports, written approach (emails) and desk research (in cases where neither interviews nor written approaches gave any results), the Study team managed to gather a total of **22 good practices in digitalisation.**

Within the European Union, good practices in digitalisation were identified in the following countries and ports:

- Belgium: Port of Antwerp (three good practices),
- France: Port of Strasbourg, the ports of Rhône and HAROPA Port,
- Germany: Port of Trier and the RhinePorts,
- Hungary: Port of Győr-Gönyü,
- Spain: Port of Seville.

On an **international level (world and non-EU European countries)**, the study team managed to collect good practices in the following countries and ports:

- Bangladesh: Pangaon Inland Container Terminal,
- Canada: Port of Montreal (two good practices) and Port of Trois-Rivières,
- China: Port of Shanghai, Port of Hefei and Port of Wuhu,
- Colombia: Port of Barranquilla,
- Serbia: Port Governance Agency (national port authority),
- Vietnam: Port of Haiphong (two good practices),
- United Kingdom: Port of London.



Picture 1 – Map with EU and international good practices

2.2 Categories of identified digital tools

During the identification of suitable digital tools applied by inland ports in EU and internationally, the Study team encountered nearly as many categories of digital tools as the number of ports identified.

Identified digital tools include, but are not limited to, the following:

- Port community systems,
- Barge traffic management systems,
- Truck traffic management system,
- Gate operating systems,
- Reporting and invoicing digital platforms,
- Port management and information systems,
- Digital information exchange platforms,
- Intra-port rail traffic management,
- Digital twins,
- Automated workforce management,
- Blockchain-based document management systems,

- 5G technology for port automation,
- Digital invoicing and reporting platforms,
- Digitalised cargo management,
- Terminal operating systems,
- Digital environmental monitoring tools.

Port Community Systems (PCS) represent an electronic platform that connects the multiple systems operated by different organisations and stakeholders that altogether form an inland port community. It is shared in the sense that it is set up, organised and used by stakeholders in the same sector – in this case, a port community.[6] By definition, it is a neutral and open electronic platform that enables intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the ports' communities.[7] Port Community Systems are, essentially, a major node of a communication, processing and information and documents exchange network, composed of shipping agents, shippers, freight forwarders, transporters, terminals, logistics platforms, and other relevant public and private entities. PCS focuses on service level, partner networks, vessel services, freight services, logistical services, and advanced port services.[8] Port Community Systems therefore offer functions such as: information sharing, cargo tracking, customs integration, booking reservations, documents exchange, billing and invoicing, collaborative services, etc.

Barge traffic management systems or platforms serve primarily for the management of inland vessels in a port. They can assist barge operators in booking the berths at relevant terminals in advance or offering them the possibility to book both berths and time slots reserved for each barge. Typically, this category of digital tools also provides information such as lock status, positions details, various navigation related messages, etc.

Truck traffic management systems or platforms, similar to the barge traffic management systems, play an important role of optimising the truck traffic within ports and/or near the approaches to ports, thus avoiding unnecessary idling times or queuing at typical "choke points" of ports. Depending on the sensor technologies combined within the truck traffic management system, such systems may, for instance, enable port managers and operators to follow the truck movements at the gates or within the port area in real-time, or to manage entrance and exit of trucks in the port area. This gives them the possibility to take actions and measures aimed at avoiding over-queueing and certain areas and to increase safety.

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[6] IPCSA (2015). *How to develop a Port Community System*, IPCSA Guide. Available at: https://ipcsa.international/wp-content/uploads/2020/07/ipcsa-guide-english-2015.pdf

[7] Long, A. (2016). Port Community Systems Role in Enhancing the Efficiency of European Ports, *European Sea Ports Organisation (ESPO) Conference*, Dublin. Available at: https://www.assoporti.it/media/1201/4_ipcsa-alan-long.pdf

[8] Caldeirinha, V., Nabais, J.L., Pinto, C. (2022). Port Community Systems: Accelerating the Transition of Seaports toward the Physical Internet—The Portuguese Case. *Journal of Marine Science and Engineering*, 10(2). Available at: https://doi.org/10.3390/jmse10020152

Gate Operating Systems (GOS) in inland ports encompass software and hardware solutions designed to optimise and manage the flow of traffic at the entry and exit gates of a port or terminal. These systems have an important role in boosting security, efficiency, and data accuracy within the port's gate operations. They facilitate more efficient traffic management, appointment scheduling, automated truck identification, access control and security checks, document verification, billing and invoicing, etc.

Reporting and invoicing digital platforms are digital solutions enabling users to exchange data, report the arrival of vessels, trucks, trains or cargoes in the port of posterior handling. In addition to that, as all necessary parameters are input in the platform, the users can proceed to invoicing of their services provided to other users. Moreover, some other more advanced reporting platforms provide performance metrics, visualisation, customisable reports and sometimes even data analytics.

Port management and information systems are typically software solutions offering broader services than Port Community Systems, such as services for managing and monitoring port operations. Additionally, such systems include functionalities such as infrastructure management, cargo handling management, berth allocation and management, financial management and different administrative tasks, offering important insights and decision-making support.

Digital information exchange platforms are digital tools similar to reporting tools and enable users to exchange necessary information related to the vessels calls, inward or outward haulage of export/import cargo, arrival and departure of trucks and trains, information on cargo owners or receivers and shippers, cargo declarations, customs documents, etc.

Intra-port rail traffic management digital tools are designed to optimise and manage rail traffic at the port railway gates and on the internal network of port railways. Utilising advanced algorithms and analytics, such systems enable digital traffic control for the port's railway, allowing for efficient management, scheduling, and optimisation of rail movements. These systems facilitate automated data capture such as wagon and container numbers, weight measurements, comprehensive surveillance, data transmission, etc.

Digital twins are, in a nutshell, virtual replicas or representations of physical assets, systems, and/or processes. These virtual replicas are typically fed with real-time information on the status of assets, conditions of the surroundings, and processes in ports thanks to a variety of the Internet of Things (IoT) sensors and cameras deployed throughout the port. From the point of view of port infrastructure and operations, digital twins offer several benefits, such as simulation and visualisation, optimisation of work processes and energy consumption, improved decision-making, improved operations, and risk management.

Automated workforce management tools are designed to assist the operation planning staff in ports to plan the engagement of port labour (dockers) according to the realistic predictions of vessel arrivals and cargo accumulation in ports. These tools typically hold vessel predictions functionalities, as well as the tools to analyse port traffic, weather conditions and

cargo details to propose an optimal labour dispatch scenario, taking into account the availability of dockers and their necessary skills.

Blockchain-based document management systems are generally designed as a decentralised and distributed ledger, enabling transparency, security and stability of data. In a blockchain application, port operators and shipping carriers communicate with each other, exchanging data in a real time, such as cargo bills of lading or cargo manifests. Various documents can be accessed by involved stakeholders, that is, by those who are authorised to access certain documents by data owners. This can significantly increase the speed of cargo delivery. For example, upon receipt of payment, the carrier can acknowledge the payment and authorise the cargo delivery to receiver in the application, while the terminal can prepare the delivery order and authorise the trucking company to take over the cargo.

5G technology for port automation is a building block for automation processes in ports as 5G networks provide seamless and real-time transfer of signals and information. In case of ports, an operating software (typically a Terminal Operating System – TOS) can control automated (or remotely operated cranes and other cargo handling equipment, and for the safe and accurate transfer of signals, commands and information/data, a TOS needs fast and reliable connection with the automated equipment. This is where 5G networks step in, thanks to its extraordinary features in terms of data and signals transfer.

Digital invoicing and reporting platforms, as well as digital payment systems are either standalone applications (software) or web-based platforms that allow users to exchange information and relevant documentation related to cargo, land transportation vehicles, vessels, passengers, or crews. In addition, many of these applications or platforms can calculate relevant fees thus enabling the users to create invoices related to port operations.

Digital cargo management tools include cargo tracking within the port limits, inventory management and control and clearance of cargo leaving or entering the port area. These tools provide real-time insights into the location, status, and condition of cargo, enabling port operators to monitor and manage cargo movements efficiently and safely.

Terminal operating systems, or shortly TOS, are software designed to be used in the port industry to manage and control the various operations of a terminal. It provides a centralised system for the efficient handling and monitoring of cargo, vessels, equipment, and crew. The TOS integrates with other systems, such as GPS, Electronic Data Interchange (EDI), and mapping software, to facilitate real-time data analysis and streamline workflow. The main features of a Terminal Operating System include inventory management, cargo scheduling and planning, yard and vessel management, and security control. The TOS allows for the automation of processes, reducing human error and improving productivity. It provides a user-friendly interface for easy navigation and reporting, making it a valuable tool for terminal operators and industry stakeholders.[9]

[9] https://terminaloperatingsystem.com

Digital environmental monitoring tools are software solutions or web-based platforms enabling users to create inventory data and analytical features related to the established sets of environmental key performance indicators, as well as to create environmental reports. These tools can use real-time environmental data originating from different IoT sensors collecting and transmitting data on air and water quality, noise, and other environmental parameters of choice from predetermined. Other types of digital environmental tools use various models for ship emissions based on ship data and characteristics, combined with Automatic Information System (AIS) data on vessel location in the port areas and port approaches, thus creating the so called "heat maps" in the areas where vessels pass or accumulate for operational or other purposes. This, in turn, can give a picture of detailed emissions inventory of a determined number of pollutants in monitored areas.

The following good practises described in Chapter 3 and 4 rely primarily on the descriptions provided by the respective users/owners/providers or manufacturers of the tools, and on the interviews with the selected stakeholders.

03

Good practices in the European Union

3.0 Good practices in the European Union

3.1 Port of Sevilla – Posidonia Operations

Basic data	Description
Location of the port:	Sevilla, Spain
Inland waterway:	Guadalquivir
Category of digital tools:	Port Operations Management System
Stakeholders involved:	Puertos del Estado[10], Port Authority of Sevilla[11], ProDevelop[12]
Description:	The Port of Sevilla is the only inland port in Spain. It is a strategic location for the European Union and fully multi-modal in operation, with sea, rail and road connections. It has 850 hectares dedicated to logistics and industrial uses and is a leader in agro-food products, steel and containers. It has the first Logistics Activity Zone in Andalusia, a Free Trade Zone and cruise terminal right in the centre of the city. It is one of the principal nodes in the Core Network and forms part of the Mediterranean Corridor of the TEN-T, and also of the Atlantic Corridor with the navigable section of the Guadalquivir River, given the importance of inland navigation routes in Europe. **Applied digital tool**: Posidonia Operations Posidonia Operations represents a comprehensive Port Operations Management System that allows a port to enhance the efficiency of maritime activities associated with vessel movement within its service region. This is achieved by integrating all pertinent information systems and involved stakeholders. The system revolves around the vessel, with all activities and data intricately linked to it through an integrated operator panel. This panel

[10] https://www.puertos.es/en-us
[11] https://www.puertodesevilla.com/en/port-authority
[12] https://www.prodevelop.es/en/ports/posidonia

	serves as a centralised hub, gathering pertinent information from various external sources and systems. Posidonia Operations functions as a global real-time vessel activity monitoring system, proficient in identifying numerous events throughout a vessel's lifecycle during its port call. This capability not only enables process automation but also aids port operators in effectively overseeing and managing the various aspects of a vessel's stay in the port. Posidonia operations covers the following phases of vessel traffic: 1) port call request, 2) port call authorisation, 3) approaching the port, 4) berth change, 5) docking and undocking, 6) entrance to the service zone, 7) entering and exiting the anchorage area, 8) leaving the port, 9) step-by-step passage control. In addition, the software solution includes the management of the following vessel operations: 1) berth planning, 2) coordination and registration of pilots, tugs and mooring men (linesmen), 3) vessel supplies, 4) waste removal, 5) incidents, 6) repairs, 7) inner port traffic.
Realised/potential impact	**Key impacts:** ▶ Centralisation of all information related to vessel operations. ▶ Improved efficiency of port operations control, thanks to automatic event detection and operator assistance. ▶ Seamless integration with external systems, such as PMS, PCS, etc. with no need to enter information in multiple applications or use multiple displays. ▶ Improved data quality of operations, through working with different data sources such as AIS, radar, VTS, PMS, PCS, etc. ▶ Port security support. **Environmental benefits:** ▶ Fuel efficiency thanks to optimised vessel movements and activities within the port. ▶ Emission reduction due to streamlined operations and optimised vessel movements.

3.2 Port of Győr-Gönyü – Information exchange platform

Basic data	Description
Location of the port:	Győr-Gönyü, Hungary
Inland waterway:	Danube River
Category of digital tools:	Web-based reporting and documents exchange tool
Stakeholders involved:	Győr-Gönyü Public Port Operator Company
Description:	Győr-Gönyü port is located on river km 1794 of the Danube River, at the junction of several national transit railways of high importance and motorways. The port is directly connected to European Highway E60 leading from Brest to Constanta, and to highway system E75 Helsinki-Athens and Ystad-Rijeka. The port has a total area of 1,000,000 m^2. It handles dry bulk, break-bulk, general cargo, heavy cargoes, Ro-Ro cargo, oil derivates and containers. It has 0.69 km of berth length and five terminals, with the average annual throughput of 300,000 tons of different cargoes. **Applied digital tool**: Web-based info exchange platform. The customer centre on the port operator's website offers clients a user-friendly interface for seamless interaction and document management. Upon accessing the website, clients can register and log in to the customer centre. The platform serves as a comprehensive document-sharing hub, enhancing communication between users and the port operator. Key features of the tool are the following: ▶ Document sharing. Clients can easily upload scanned PDF documents related to various aspects of their shipping activities. This includes essential documents such as shipping documents, cargo and crew manifests, vessel-related paperwork, and other pertinent records. ▶ Messaging and information exchange: The platform facilitates effective communication by allowing users to exchange messages and information directly with the port. Users can discuss shipping

	details, coordinate logistics, and address any queries or concerns through the integrated messaging system. ▶ Data categories: The platform covers a broad spectrum of data categories, including vessel features, origin and/or destination of goods, cargo details, and information about stakeholders involved in the shipping process. This encompasses cargo shippers, receivers, agents, forwarders, customs agents, and more. ▶ Manually entered data. While the platform offers a robust document-sharing system, it is important to note that, at this stage, the platform is not directly integrated with River Information Services. Consequently, certain data may need to be entered manually by users. This includes details that are not automatically retrieved from external sources. ▶ User-friendly interface. The customer centre provides an intuitive and user-friendly interface, ensuring that clients can navigate the platform with ease. This simplicity encourages efficient data entry and retrieval. ▶ Accessibility. Clients have secure and convenient access to the platform at any time, enabling them to manage their documents and communication with the port operator from anywhere with an internet connection. ▶ Document verification and compliance: The platform supports document verification processes, ensuring that submitted documents adhere to regulatory and compliance standards. This feature increases the reliability and accuracy of the shared information. ▶ While the platform currently requires manual data entry for certain information due to the lack of integration with River Information Services, it serves as a useful tool for clients to streamline communication, manage documentation, and engage with the port operator in a collaborative and efficient manner. As technology advances, future integrations may improve automation and further optimise data exchange processes.
Realised/potential impact	**Key impacts:** ▶ Better communication. ▶ Streamlined information exchange. ▶ Improved collaboration.

	▶ Time and cost savings. **Environmental benefits:** ▶ Reduced paper usage. ▶ Lower energy consumption due to faster and more efficient processes. ▶ Reduced emissions thanks to the reduced physical distribution of documents.

3.3 Port of Strasbourg – VIGIE

Basic data	Description
Location of the port:	Strasbourg, France
Inland waterway:	Rhine River
Category of digital tools:	Port information and management system
Stakeholders involved:	Grand Port Maritime de Bordeaux, Port Autonome de Strasbourg (PAS), Regional Customs Directorate
Description:	▶ The Autonomous Port of Strasbourg (PAS) stands as the second-largest river port in France, boasting a traffic volume comparable to numerous seaports. Serving as the maritime gateway for the eastern region of France, it plays a vital role in facilitating trade and logistics activities. Situated on the left bank of the Rhine River, 40 hours of navigation from the North Sea, PAS provides strategic access to vital maritime routes. Encompassing 1,050 hectares in Strasbourg, PAS serves as a key economic driver in the region. With 200 hectares dedicated to docks, the port spans 10 kilometres in length and 1 kilometre in width. With an extensive rail network spanning 100 kilometres, PAS guarantees smooth connectivity, facilitating efficient inland transportation. The port is a home to 500 businesses and generates more than 10,000 jobs, significantly stimulating economic

growth and local employment. In 2023, the port handled 6,181,665 tons of goods and a total of 342,414 TEUs.[13]

- **Applied digital tool:** VIGIE (a.k.a. VIGIEsip)
- The Autonomous Port of Strasbourg introduced VIGIE on 1 January 2019. This port dues declaration tool, developed by the Grand Port Maritime de Bordeaux, is tailored for both river transport of goods and passengers. While VIGIE was initially developed for seaports, its application in the Autonomous Port of Strasbourg is a new move for a river port. VIGIE streamlines the declaration of port dues, enabling the complete paperless information exchanges among companies, PAS (Port Autonome de Strasbourg), and customs services. By digitising administrative processes, VIGIE contributes to time and productivity savings for all stakeholders involved in port operations. VIGIE was designed in collaboration with the Regional Customs Directorate, and its adoption incurs no additional costs for businesses. Approximately 100 PAS companies, encompassing river freight carriers and cruise ships, have made use of VIGIE, signing user agreements to benefit from its features. The user-friendly tool is accessible through an internet browser, ensuring ease of access and navigation. The tool facilitates the generation of monthly and annual river statistics, enhancing data-driven decision-making.[14]
- VIGIE is an application made available in SaaS (Software As A Service) mode but can also be installed on a port's servers. VIGIE relies solely on “Open Source” software components such as PostgreSQL (database), Jasper Reports, JAVA, JSF, Primefaces, etc.
- A version for smartphones is also available: it is VIGIEsip, a hybrid mobile application under IONIC and Angular, downloadable from the Android and IOS stores.[15]
- The application has a large number of modules, all of which are either directly applicable for inland ports or they can be quickly adapted to the conditions prevailing in inland ports. Some of the modules are:[16]
- Port Access Badges Command Portal: Users can request access badges through the VIGIEsip registration portal, and the requests are processed by ASIP.

[13] https://www.strasbourg.port.fr/pas-group/annual-figures/?lang=en
[14] https://www.strasbourg.port.fr/actualites/vigie/
[15] https://www.vigie-ports.fr/service-portuaire-numerique/vigiesip/
[16] https://www.vigie-ports.fr/vigie-systeme-dinformation-portuaire/

- River Module: Automatic integration of annual programs from company Excel files and monitoring changes on the VIGIEsip weekly schedule.
- Handling Calls Programs (ferry, cruise ship, etc.): Automatic integration of programs through Excel files.
- Environmental Dashboards / PIXEL: Graphic presentations of PEI (Port Environmental Index) over periods and energy modeling of calls based on the port's electrical supply capacity.
- Incident Management: Log of incidents related or unrelated to ships in port.
- Traffic2000/CCS Exchange Monitoring Dashboard: Tracks all messages sent and received with their status (failure, success, information on failure).
- Alerts Module: Manages configurable email or screen alerts by event and recipient.
- Real-time Ship Tracking (AIS) and Replay Module: Real-time visualisation of ship positions on a map and the ability to replay situations over a period.
- Service Billing and TOP (Turnover of Operations) Module: Invoice input or automatic billing based on a tariff grid.
- Port Dues Declaration Module: Manages ship and cargo declarations and monitors customs visas.
- Ordering Module for Ship Services: Access to services from ship movement requests and ordering these services. Port monitors service requests.
- Harbor Master Messages: Internal log for the harbour master.
- Container Yard MD (Dangerous Goods) and Prescriptions Tracking Module: Automatically generates prescriptions based on local MD regulations and FAL7 data, and tracks containers in the yard in conjunction with the mobile application.
- Quay Occupation Forecasts: Weekly view of quay occupation forecasts and docked ships.
- Quay Characteristics: Tracks maximum dimensions of ships that have docked by quay and sector.
- Statistics Management and DTM/Eurostat Reporting Module: Manages ship and cargo statistics based on the NST2007 reference and generates control and regulatory reports for DTM and Eurostat.

	▶ On-board Declaration Module for Pleasure Craft: On-board module for declaring regulatory formalities for ships without an agent, particularly pleasure craft. ▶ Berth and Mooring Module: Automatic placement of announced and docked ships on a map and calendar and mooring management. ▶ Public APIs for Docked and Expected Ships: RESTful web services providing public data in JSON format. ▶ Piloting Module: Monitors ships to be serviced on VIGIEsip and sends missions via notifications on the mobile application with acknowledgment. ▶ Operation Findings Management (under development): Entry of operation times by equipment and teams, data restitution in dashboards. ▶ Annual Cruise Forecasts Module (under development): Annual schedule for collecting cruise ship calls with restricted actions and visualisation based on authorisations. ▶ Turbidity Collection and Monitoring Module (under development): Processes IoT data (flowmeter, connected buoy, etc.), triggers mobile application notifications based on thresholds, and displays monitoring graphs in VIGIEsip for dredging operations. ▶ Harbour Master Forum (under development): Exchange and information-sharing forum among all harbour masters on VIGIEsip. Communication of ships to follow for incidents.
Realised/potential impact	**Key impacts:** ▶ Streamlined port and customs operations. ▶ Time and efficiency gains. ▶ Increased transparency, accessibility, and collaboration (“Open Source”). **Environmental benefits:** ▶ Reduced paper consumption ▶ Monitoring of environmental parameters of port operations.

3.4 Port of Trier – DigiTest Optimal Character Recognition

Basic data	Description
Location of the port:	Trier, Germany
Inland waterway:	Moselle
Category of digital tools:	Land (rail) traffic management
Stakeholders involved:	Hafen Trier (port authority), Federal Ministry for Digital and Transport (BMDV), Rail operators
Description:	Port of Trier is located on the river km 184 of the Moselle River, at the confluence with the Saar River. The port has a direct access to the inland waterways of the Saar (91 km) and Moselle (364 km) rivers, which in turn are linked to the network of European inland waterways and maritime routes. It has a total quay length of 900 m and 7.5 km of internal railway, and it handles an average amount of 1.3 million tons of various cargo. Average modal split between the rail and inland waterway cargo handling is 60:40 in favour of the rail transport. The port is a trimodal transport hub with an extensive range of services. The main goods handled are solid and liquid bulk goods such as petroleum and mineral oils, ores, non-ferrous metals, chemical products, stones and soil, food and feed as well as agricultural and forestry products. **Applied digital tool**: DigiTest Optical Character Recognition (OCR) system for railway. The Port of Trier is finishing the development of a digital tool for the rail traffic control in the port, based on the OCR system. This initiative is part of the "Digital Test Fields in Inland Ports" (DigiTest) project funded by the Federal Ministry for Digital and Transport (BMDV). The focus is on creating a digital test field specifically tailored for traffic control on the port's railway.[17] The primary objective of implementing the OCR system in railway traffic control is to automate and streamline the current processes, which are conventionally managed by railway companies via C-radio. The

[17] https://www.hafen-trier.de/2023/11/14/digitalisierung/

automation aims to significantly simplify the control of rail traffic within the port, introducing a shift in efficiency and data accuracy. The following are the basic components:

- OCR Gate: The OCR gate serves as the centrepiece of the system, employing advanced optical character recognition technology. This gate utilises video recording to automatically capture and process information as trains, wagons, and containers enter or exit the port.
- 5G Network infrastructure: A 5G campus network is being established within the port premises. This high-speed, low-latency network forms the backbone for seamless communication between various components of the OCR system.
- Video cameras: Multiple cameras, strategically positioned along the railway tracks, facilitate comprehensive video surveillance. These cameras play a crucial role in capturing real-time footage of incoming and outgoing trains, wagons, and containers.
- Integrated track scale (weigh): The OCR gate incorporates an integrated track scale, providing an additional layer of functionality. This scale automatically determines the weight of each wagon, providing useful data on the load carried by the trains.
- Tailor-made software solution: The Port of Trier is procuring a custom-made software solution to manage and monitor the entire OCR system. This software will serve as the digital backbone, coordinating data processing, analysis, and system control.

The system functions in the following way:

- Automated data capture: As trains and associated cargo pass through the OCR gate, the system utilises video recording to automatically capture essential information, including wagon number, container number, and entry/exit timestamps.
- Weight measurement: Simultaneously, the integrated track scale accurately measures the weight of each wagon, contributing crucial data for load management and logistical planning.
- Comprehensive surveillance: Additional cameras along the tracks provide a comprehensive view of the occupancy status of individual track sections. This data enriches the system's understanding of the railway infrastructure's real-time conditions.
- 5G Data transmission: The captured data from the OCR gate, track scale, and cameras is transmitted in real-time through the

	established 5G campus network. This ensures swift and reliable communication between the various components. ▶ Digital traffic control: The transmitted data is then processed on a centralised server. Utilising advanced algorithms and analytics, the system enables digital traffic control for the port's railway, allowing for efficient management, scheduling, and optimisation of rail movements.
Realised/potential impact	**Key impacts:** ▶ Improved railway planning and rail traffic management in the port. ▶ Improved safety. ▶ Enhanced logistical insights. **Environmental benefits:** ▶ Reduced energy consumption due to optimised traffic flows.

3.5 Ports of Rhône – Ci5 Port Community System

Basic data	Description
Location of the port:	Lyon, Arles, Avignon, Portes-les-Valence, Salaise-Sablon, Lyon, Villefranche-sur-Saone, Macon, Chalon-sur-Saone and Pagny, France
Inland waterway:	Rhône River
Category of digital tools:	Port Community System
Stakeholders involved:	French State, Compagnie Nationale du Rhône (CNR), Marseille Gyptis International (developer)
Description:	The Ports of the Rhône comprise 22 industrial and port sites of which 18 are linked to the river, including Port de Lyon, managed by CNR. They are located about every 20 km along the River Rhône, a strategic corridor between northern and southern Europe and connected to world trade routes via the ports of Marseille/Fos and Sète.[18] The Rhône ports are an

[18] https://www.cnr.tm.fr/en/river-transport/the-rhone-ports/

important economic entity covering 100 hectares of land, encompassing 22 industrial and port sites, 18 of which are directly linked to the river. They host 220 companies along the Rhône's banks, supporting approximately 5,500 jobs across various sectors.

Applied digital tool: Ci5 Port Community System

The main goal of the newly developed PCS is to boost French ports attractivity, by connecting maritime ports to their natural hinterlands, with promoting barge and rail transportation. It translates French State's will to create a competitive maritime-river link between French Mediterranean Ports, including Marseille, and the Rhone-Saone River. The port of Lyon gathers 80% of barge activity. The ambitions have been translated into several workstreams, including one on energy and digital transition, which hosts the said digitisation project "Axe Sud". "Axe Sud" is a 2 years plan, in order to digitise the logistic chain: all operational steps are involved, from freight preparation, loading/unloading, transport between Maritime and Inland Ports, up to final delivery. Customs declarations activity is also covered.[19]

Ci5 is a PCS designed to optimise the management of goods flow, enhancing fluidity, traceability, security, and competitiveness across all terminals. By integrating cutting-edge technologies like Big Data, IoT, Artificial Intelligence, smart containers, and blockchain in Ci5, supply chain stakeholders have better control and management capabilities. It enables increased operational productivity through personalised interfaces, user-friendly input methods, and simplified data retrieval. With real-time access to information, supply chain participants can plan and coordinate all land and maritime activities in anticipation of vessel arrivals or departures, as well as for other transport modes. For example, the Ci5 mobile application streamlines the entry process for carriers at terminal gates, while truck drivers swiftly input container and seal numbers, reducing data transmission times and expediting goods movement. Ci5's core functionalities cover a wide range of import and export operations, including goods notification, unloading, customs clearance, terminal exit, and door-to-door tracking via connected inland terminals. It also automates material accounting and allows secure docking, booking tracking, customs clearance, and loading onto maritime vessels. The system can be coupled with Da5, a Business Intelligence service that enables data analysis and integration throughout the port supply chain.

[19] E-mail communication with CNR on 29.01.2024.

	Additionally, Ci5 provides specialised services such as Bulk Management for unpackaged goods, Container Stuffing and Unstuffing for traceability, Dangerous Goods Management for hazardous materials, and port duty calculation with the DN/DSM service. MGI Connect API and MGI Connect EDI provide dynamic data coupling and interface capabilities, enhancing productivity and operational efficiency while minimising errors.
Realised/potential impact	**Key impacts:** ▶ Improved operational efficiency. ▶ Enhanced supply chain coordination. ▶ Increased productivity. ▶ Better traceability and security. ▶ Performance. ▶ Increased trade security and data confidentiality. ▶ Improve service quality. ▶ Identification of anomalies. ▶ Increased competitiveness of involved stakeholders. **Environmental benefits:** ▶ Improved modal shift towards rail and IWT. ▶ Reduced carbon emissions by streamlining operational processes and reducing delays. ▶ Reduced paper usage.

3.6 Rhine Ports – RiverPorts Planning and Information System

Basic data	Description
Location of the port:	Ports along the Rhine: Basel, Weil am Rhein, Strasbourg, Mulhouse, Colmar, Kehl, Karlsruhe, Mannheim, Ludwigshafen and Duisburg. Germany, Switzerland and France.

Inland waterway:	Rhine River
Category of digital tools:	Port Community System (PCS)
Stakeholders involved:	RheinPorts GmbH, Hamburg Port Consulting,
Description:	Upper Rhine Ports represent a conglomerate of inland ports on the upper section of the Rhine River. The ports of Basel, Weil am Rhein, Strasbourg, Mulhouse, Colmar, Kehl, Karlsruhe, Mannheim, Ludwigshafen, with Duisburger Hafen (Duisport) being their latest shareholder, formed a company RheinPorts GmbH back in 2017 for the purposes of cooperation and development. These ten ports represent a high concentration of industry and logistics, with more than 100 million tons of cargo handled every year, more than 5 million TEU, providing direct jobs to more than 72,000 people. **Applied digital tool**: RiverPorts Planning and Information System (RPIS) Since 2014, a collaborative effort among the ports of Basel, Mulhouse, Weil am Rhein, Colmar-Neuf-Brisach, Strasbourg, Kehl, Karlsruhe, Mannheim, and Ludwigshafen, with the support of European funding programs CEF and Interreg, has been underway to develop the RiverPorts Planning and Information System (RPIS). This platform represents a leap forward in traffic management for barge handling, enhancing operational efficiency across the board.[20] At its core, RPIS aims to unite the various stakeholders within the European hinterland logistics port industry. By facilitating the exchange of crucial data and information among these stakeholders, RPIS streamlines processes with simplicity and accessibility. Efficient port operations necessitate not only modern terminal infrastructure but also a state-of-the-art digital framework. Recognising this need, the Upper Rhine Ports spearheaded the development of RPIS as a barge reservation system for inland ports. Through a neutral integrated service platform, RPIS enables transparency in processes and facilitates resource planning, thereby enhancing efficiency, reducing operational costs, and providing service quality for all users involved. Barge operators can reserve slots at multiple terminals along the Upper Rhine through a single, centralised

[20] https://rheinports.eu/en/

	system, while terminals manage slot reservation requests and provide timely responses, and scheduling optimised round-trip for barges is possible. Real-time information within RPIS ensures users are promptly informed about barge positions and any delays, with the system issuing warnings to other involved parties in the event of a delay. Moreover, RPIS provides further functionalities, including coordinating barge calls, booking berthing slots, data exchange and administration, visualisation, container management, customs modules, ship position tracking, and cargo information. While RPIS currently lacks predictive capabilities and extensive data analysis features, plans are in place to introduce further functionalities. These include berth reservation services for cruise and bulk vessels, digital invoicing and statistical analysis tailored to specific vessel types, train position tracking, prediction of waiting/loading times based on historical data, and the integration of AI technologies. Future iterations are poised to incorporate technologies such as IoT, Big Data, Artificial Intelligence, Blockchain, and Drones. RPIS provides improved efficiency and better collaboration for the ports along the Upper Rhine and beyond.
Realised/potential impact	**Key impacts:** ▶ Better operational efficiency due to streamlined port operations. ▶ Cost reduction through minimisation of idle times of both barges and terminals. ▶ Improved service reliability and quality. ▶ Increased transparency. ▶ Competitive advantage by offering advanced digital infrastructure and streamlined processes. ▶ Facilitated cross-border trade by simplifying administrative procedures and minimising delays at port terminals. **Environmental benefits:** ▶ Reduced emission by optimised barge scheduling. ▶ Promotion of sustainable transport and positive modal shift.

3.7 HAROPA Ports – Passage Plan

Basic data	Description
Location of the port:	Le Havre, Rouen and Paris
Inland waterway:	Seine
Category of digital tools:	Digital Twin
Stakeholders involved:	Port authority, transport operators, terminal operators, shippers.
Description:	The ports of Le Havre, Rouen and Paris are the constituent parts of the Major Seine axis River- and Seaport. In essence, HAROPA is a "multiport" cluster, encompassing the ports and terminals in the seaport of Le Havre and inland waterway ports of Paris and Rouen on the Seine River. HAROPA PORT, a major player in France's maritime and inland waterway sector, consists of a Head Office and three Territorial Departments located in Paris, Rouen, and Le Havre. The Head Office in Le Havre oversees strategic aspects such as management, development, and communication along the Seine Axis. The Paris Territorial Department focuses on final-kilometre logistics and river transport, boasting a network of 6 multimodal platforms and 70 urban ports. The Rouen Territorial Department specialises in handling diverse port traffics, particularly industrial, along the Seine, positioning HAROPA PORT as a leader in grain exports. Lastly, the Le Havre Territorial Department maintains the port's status as France's leading container port and oversees significant development projects, including expanding dock length and facilitating direct port access for river barges. With dedicated teams and extensive infrastructure, HAROPA PORT continues to play a crucial role in France's maritime and inland waterway landscape.[21] **Applied digital tool:** Passage Plan The fluidity and safety of the traffic of vessels through the port and goods to and from the hinterland are two priority issues for which digital innovation is a source of opportunities.

[21] https://www.haropaport.com/en/our-identity

	Therefore, HAROPA PORT has developed a predictive digital tool that makes it possible to accurately predict and manage the entries and exits of the ships, as well as the port-call time: Passage Plan. Passage Plan is based on the integration and synchronisation of various data: nautical and meteorological conditions, characteristics of the vessel, nature and volume of the goods transported, condition of gantries, dock stay, availability of infrastructure and manpower. Three digital pillars constitute the Passage Plan's architecture: ▶ myETA: an application which allows a precise visibility of the end-to-end journey of the goods – granted that the Estimated Time of Arrival – ETA is a central element determining port call times and conditioning all transport and logistics flows. ▶ Digital Twin: through the combination of Artificial Intelligence (AI), IoT and 5G – the latter allows users to have a precise knowledge of the level of the seabed/riverbed, of the navigation channel or the height of the swell. ▶ My T&T: a tracing solution which makes it possible to accurately obtain the logistical steps of the goods up to their collection. HAROPA PORT can optimise the productivity of port operations and the use of associated resources and therefore strengthen the quality of services offered to its customers.[22] By using a digital twin such as Passage Plan, a port can anticipate and improve the operational efficiency of calls and optimise the management of the associated operations & resources. Passage Plan can also contribute to reducing the energy consumption associated with port activities and contributes to the reduction of environmental impact.
Realised/potential impact	**Key impacts:** ▶ Cost reduction due to optimised operational processes and reduced idle time of vessels. ▶ Improved customer service due to increased reliability and time punctuality for cargo handling services. ▶ Optimised use of resources due to real-time visibility into port activities and resources availability.

[22] E-mail communication with Mr. Tommaso Spanevello of the HAROPA PORT, concluded on 14.02.2024.

	▶ Streamlined logistics due to accurate visibility of end-to-end journey times for goods and tracing solutions for logistical steps. **Environmental benefits:** ▶ Improved environmental sustainability due to reduction of energy consumption resulting from optimised operations and resource utilisation. ▶ Emission reduction due to optimised vessel movements and port call times, which helps reduce emissions of air pollutants such as nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter (PM).

3.8 Port of Antwerp – Qless vehicle booking system

Basic data	Description
Location of the port:	Antwerp, Belgium
Inland waterway:	Scheldt River
Category of digital tools:	Vehicle Booking System
Stakeholders involved:	DP World (terminal operator), QLess Inc. (platform developer)
Description:	Port of Antwerp, now doing business as a twin port known as Port of Antwerp-Bruges, is the second largest port in Europe. It handles both maritime and inland waterway vessels, thus being classified as sea-inland port. The port's maritime cargo throughput reaches nearly 300 million tons annually, while the overall annual cargo throughput using inland vessels exceeds 100 million tons.[23] The Antwerp Gateway terminal[24], operated by DP World, is one of the numerous terminals of the Port of Antwerp-Bruges, where 35% of the total cargo throughput (to/from the terminal) is transported by barge. Via the Albert canal, Antwerp Gateway is linked by waterway to the most important logistic hotspots in Belgium. Regular barge shuttles link the DP

[23] https://www.portofantwerpbruges.com/en/faq/where-can-i-find-facts-figures-and-statistics-about-port
[24] https://www.dpworld.com/en/belgium/connectivity/barge

World terminal in Liège (Trilogiport). Antwerp Gateway has a dedicated barge quay ensuring inland vessels have guaranteed berths.

Applied digital tool: QLess vehicle booking system.
At the Antwerp Gateway terminal, more than half of all containers loaded on or discharged from vessels arrive or leave by truck, which creates large lineups of idling vehicles waiting to drop off or retrieve cargo.[25] Realising that their operations were needlessly causing congestion and traffic bottlenecks, a terminal took action by implementing digital tools for queue management. With the assistance of QLess digital tool, truck drivers were able to wait remotely, eliminating the requirement to wait in their idling trucks. Between 1,400 to 2,400 trucks funnel through the Antwerp Gateway Terminal each day with their engines running while waiting to enter, creating a huge challenge to find a solution that could integrate into the existing complex terminal system and work solely by using APIs (Application Programming Interface). Following an extensive analysis of data and processes, a strategic plan was formulated based on the Kanban Principle of pull. In this approach, trucks are strategically buffered when exchange areas approach a predetermined quota. Once the quota falls below a specified threshold, the next truck in line is promptly summoned, allowing it to advance to the handling area seamlessly. This systematic application of the Kanban Principle optimises the flow of trucks, ensuring efficient and timely operations within the handling area. In the context of trucks waiting at a terminal gate, applying the Kanban Principle of Pull involves allowing trucks to enter the terminal area only when there is a capacity to handle them. Instead of having a predetermined schedule for trucks to enter the terminal, the system dynamically responds to the current state of operations. The process might involve monitoring the availability of handling areas, ensuring that the transshipment areas do not exceed a certain capacity. For example, when the transshipment areas reach a predetermined threshold, the system would signal that the capacity is nearly full. Only when the capacity drops below the threshold, indicating that there is room for more trucks, would the next waiting truck be called forward. This ensures that trucks are introduced into the terminal handling area based on real-time capacity and demand, minimising congestion, optimising resource utilisation, and enhancing overall efficiency.

The QLess vehicle booking system team created “virtual buffer” queues and used a call-up principle to integrate with a visual board. Waiting truck drivers receive text notifications as their turn approaches but can also view their name on a video wall. Drivers are automatically

[25] https://qless.com/case/qless-helps-port-of-antwerp-reduce-carbon-emissions/

	connected throughout every stage of the port's Gate Operating System so they can use the new system without any additional touch points.
Realised/potential impact	Upon the successful implementation of the vehicle booking system for terminal capacity management, the port experienced substantial improvements. The most significant improvement was the elimination of all truck lines, ensuring that exchange areas are consistently accessible without the obstruction of hundreds of trucks in common areas. This not only streamlined operations within the transshipment zones but also eradicated traffic jams that previously occurred at the entry and exit points of the port. Consequently, truck drivers now experience significant time savings, as they no longer have to endure hours of daily waiting in lines, contributing to a more efficient and fluid operation within the port. **Key impacts:** ▶ Complete elimination of waiting queues in the terminal areas. ▶ Elimination of traffic jams at the entry and exit points. ▶ More streamlined operations and improved operational efficiency. **Environmental benefits:** ▶ Reduction of at least 730,000 kilograms of CO_2 (expected). ▶ Reduction in noise generated by idling trucks. ▶ Reduction of unnecessary delays enhance resource efficiency including a more cautious use of energy, space, and other resources, aligning with sustainable practices and reducing the ecological footprint of port operations.

3.9 Port of Antwerp – Barge Trafic System

Basic data	Description
Location of the port:	Antwerp, Belgium
Inland waterway:	Scheldt River
Category of digital tools:	Barge Management System

Stakeholders involved:	Port Authority of Antwerp-Bruges, NxtPort. (platform developer)
Description:	Port of Antwerp, now doing business as a twin port known as Port of Antwerp-Bruges, is the second largest port in Europe. It handles both maritime and inland waterway vessels, thus being classified as sea-inland port. The port's maritime cargo throughput reaches nearly 300 million tons annually, while the overall annual cargo throughput using inland vessels exceeds 100 million tons.[26] **Applied digital tool**: Barge Traffic System. The Barge Traffic System (BTS) is a web application operational since 2007 that streamlines the management of barge container traffic within the port.[27] It is an integral part of the applications package called C-point.[28] C-point is the platform for efficient digital communication between all players in the port of Antwerp. It supports and streamlines the day-to-day administrative and operational activities. C-point is an initiative of Antwerp Port Authority and Alfaport Antwerp.[29] The C-point network supports both EDI and XML variants of the electronic standard messages together with other formats and structured or generated documents. Together with NxtPort - which offers data via the technical platform – C-point forms a complete package of applications to promote digital communication between all those present in and around the port of Antwerp. The Barge Traffic System platform assists barge operators by facilitating advance requests for terminal berths. Additionally, it provides a comprehensive overview of barge positions across Flanders and the Netherlands, serving both barge and terminal operators. The BTS also offers access to nautical messages related to the port, allowing barge operators to provide advance notice of their trips. For effective traffic management in the Port of Antwerp, compliance with the BTS is mandatory for all container terminals and barges engaged in container loading or unloading. While registration is optional for other barge operators, it grants them access to relevant information such as lock scheduling, position details, and nautical messages, contributing to the overall efficiency of port operations. Upon registration, operators are able to pre-request berths at specific terminals. The BTS provides assistance by offering details on terminal opening hours, occupancy status, and any nautical constraints. For port visits involving multiple terminals, the system's built-in conflict control ensures that requested arrival times align with feasibility, considering

[26] https://www.portofantwerpbruges.com/en/faq/where-can-i-find-facts-figures-and-statistics-about-port
[27] https://www.c-point.be/en/services/barge-traffic-system-bts
[28] https://www.c-point.be/en/about-cpoint
[29] https://alfaportvoka.be

	estimated handling durations and travel times between terminals. Terminal operators are also required to register in the BTS to manage berth requests by approving, modifying, or rejecting them. In cases of conflicting requests, terminal operators can coordinate schedules through the system, facilitating effective collaboration. Schedules can be communicated from the terminal operator to the barge operator via the BTS. After a barge is handled, the terminal operator must input actual arrival and departure times, along with the number of containers handled, into the BTS. This comprehensive process increases transparency and coordination in port operations. A barge operator wishing to load or unload containers in the port uses this application to send berth requests to the terminals concerned. A conflict control system alerts the barge operator if the berth requests for different terminals are too close together in time. Once the terminal operator has drawn up its schedule it notifies the barge operator in a uniform way by means of BTS.
Realised/potential impact	**Key impacts:** ▶ Uniform method for requesting berths and sending back terminal schedules. ▶ Shorter waiting times for barges in terminals. ▶ Fewer errors (simple, one-time input and conflict control). ▶ Optimised berth allocation. **Environmental benefits:** ▶ Reduced greenhouse gasses emissions due to reduced congestion at waiting areas. ▶ Reduction of noise levels at waiting areas.

3.10 Port of Antwerp – Antwerp Port Information & Control Assistant (APICA)

Basic data	Description
Location of the port:	Antwerp, Belgium

Inland waterway:	Scheldt River
Category of digital tools:	Digital Twin
Stakeholders involved:	Port Authority of Antwerp-Bruges,
Description:	Port of Antwerp, now doing business as a twin port known as Port of Antwerp-Bruges, is the second largest port in Europe. It handles both maritime and inland waterway vessels, thus being classified as sea-inland port. The port's maritime cargo throughput reaches nearly 300 million tons annually, while the overall annual cargo throughput using inland vessels exceeds 100 million tons.[30] **Applied digital tool**: APICA (Antwerp Port Information & Control Assistant). APICA is a virtual assistant (dynamic software model of a port) that uses the input of smart cameras, drones, sensors for air and water quality, radars, RIS and AIS technologies, IoT devices and sensors, Radio Frequency Identification (RFID) technologies, and combining all this data into a virtual model (digital twin) of the port. It relies on operational and contextual data to understand how a port operationalises its business model, connects with its current state, responds to changes, deploys resources and delivers customer value. It includes the modelling of human and non-human (AI, automated activities) behaviour in port operations. APICA provides real-time information on vessel movements, flows of dangerous goods, air quality and weather conditions, but also detection of oil spills or conducts inspections of maritime infrastructure. Applying Artificial Intelligence and data science on the data in APICA will allow it to become predictive and prescriptive over time. The APICA Digital Twin solution incorporates various information layers, aggregating data on both geographical and functional levels. Geographically, it combines data from assets in the same area, while functionally, it connects assets, such as a vessel plugged to a shore-box for onshore power supply. This approach fosters situational awareness, offering real-time insights into assets across the port, encompassing traffic conditions, bridge and lock statuses, port infrastructure, and environmental sensor data.

[30] https://www.portofantwerpbruges.com/en/faq/where-can-i-find-facts-figures-and-statistics-about-port

	The APICA Digital Twin provides a detailed overview of the port's operations, facilitating timely decision-making and problem-solving. Additionally, it allows users to access historical data and near-future predictions, enhancing overall situational awareness. The ongoing investment by the APICA team focuses on integrating simulations and predictions, such as traffic forecasts, into the Digital Twin solution. This integration aims to provide a more comprehensive view of the port's operations, supporting efficient planning and preparation for potential challenges. The platform's traffic simulation forecasts, extending up to 30 minutes in advance, consider factors like historic traffic flow, tidal windows, lock planning, vessel destinations, and current and predicted traffic situations. APICA's goal is to provide additional insights into potentially hazardous situations while also providing an understanding of the emissions impact associated with simulated scenarios.[31]
Realised/potential impact	APICA digital twins revolutionised port management by leveraging technology to create virtual replicas of physical assets and operations. The impacts extend across efficiency, sustainability, safety, and collaboration, leading to a more resilient and adaptive port ecosystem. **Key impacts:** ▶ Enhanced planning thanks to the ability to simulate various scenarios within the digital twin environment, allowing the port to plan for different situations, such as traffic congestion, weather, or equipment failures. ▶ Increased operational efficiency due to optimised workflows, reduced downtimes. ▶ Resource allocation optimisation such as labour, equipment, and time. ▶ Improvement of risk identification and mitigation. ▶ Improved decision-making processes related to port logistics, traffic management, and infrastructure planning. ▶ Increased collaboration among stakeholders thanks to a shared platform for data exchange contributing to more fluid port operations and more effective communication between various port players.

[31] Bruno M. (2023) APICA: The Digital Twin Solution Transforming the Port of Antwerp-Bruges, *Port Technology*, 131, pp. 39-42. Available at: https://www.porttechnology.org/technical-papers/apica-the-digital-twin-solution-transforming-the-port-of-antwerp-bruges/

	Environmental benefits: ▶ Monitoring and mitigation of air quality through 70+ iNose sensors deployed throughout the port. ▶ Environmental sustainability through the provision of information about energy consumption, emissions, and other environmental Key Point Indicators (KPI), as well as compliance with environmental regulation

04

Good practices on international level

4.0 Good practices on international level

4.1 Port of Trois-Rivières – Traffic XHub

Basic data	Description
Location of the port:	Trois-Rivières (Canada)
Inland waterway:	St. Lawrence
Category of digital tools:	Intra-port truck traffic tracking and analysis system
Stakeholders involved:	Transport Canada's Innovation Centre, SMATS Traffic Solutions, Innovative Solutions Canada, Trois-Rivières Port Authority
Description:	As part of the 17 Canadian Port Authorities and active since 1882, the Port of Trois-Rivières is an important player in regional, national and international economic development for major industrial sectors such as the aluminium industry, forestry and agri-food. The respect of the highest environmental standards and harmony with the community are essential for the Port of Trois-Rivières. Strategically located halfway between Montreal and Quebec City, the Port of Trois-Rivières welcomes 55,000 trucks, 11,000 railcars and more than 250 merchant and cruise ships annually, originating from over 100 different ports in more than 40 countries around the world. It handles over 3.5 million metric tonnes of traffic, has an annual economic impact of nearly $220 million and supports more than 2000 direct, indirect and induced jobs. **Applied digital tool**: Traffic XHub™ with iNode™ - Truck traffic tracking and analysis system. In the recent years the port has recorded larger cargo volumes, prompting it to make significant investments in cargo terminals capacity. This has resulted in higher levels of activity. The increased influx of incoming freight has led to extended waiting periods for trucks, resulting in longer gate-times and turnaround times at the port. Consequently, this has caused traffic congestion in and around the port city and a surge in Greenhouse Gas (GHG) emissions. Faced with these challenges, port authority has sought innovative solutions to alleviate traffic congestion both in the vicinity and within the port. One of the solutions under consideration was the implementation of a truck traffic

	monitoring system. Such a system could provide valuable, readily available data on truck traffic patterns. Additionally, it could furnish actionable insights and KPI's aimed at enhancing truck movement and reducing overall port congestion. SMATS[32] (digital developer) deployed TrafficXHub™ sensors strategically throughout the port to capture Bluetooth Low Energy signals emitted by Bluetooth beacons affixed to the visiting trucks. During the installation process, the SMATS team conducted a thorough assessment of the area to determine the optimal locations based on existing mounting infrastructure and power sources. Depending on the deployment site, certain sensors were powered by solar panels, while others were connected to the available AC power supply. Truck drivers were equipped with Bluetooth beacon cards, which were either attached to their existing RFID access cards or placed inside the vehicles. These cards leveraged Bluetooth Low Energy (BLE) technology, offering the advantage of cost-effectiveness and extended battery life. The iNode™ data processing algorithms were responsible for pinpointing truck locations within the Port of Trois-Rivières and measuring their idle time, travel time, and the duration between various points. Furthermore, an origin-destination analysis tool was developed to monitor the movement patterns of trucks within the port, tracking their journey from the port gates to weighing stations, offices, product storage areas, and exit points.
Realised/potential impact	The Traffic XHub™ with iNode™ significantly enhanced the port's oversight of truck operations by furnishing a range of performance metrics crucial for both immediate and long-term planning, as well as decision-making.[33] This data proved instrumental in shaping the port's strategic decisions, encompassing asset acquisition optimisation, tactical choices aimed at enhancing the utilisation of existing assets, and operational adjustments to optimise real-time activities and augment the overall performance of the port and its terminal services. **Key impacts:** ▶ The sensors consistently delivered reliable performance year-round. ▶ Beacon cards were effectively detected along their travel routes by the sensors.

[32] https://www.smatstraffic.com
[33] https://www.smatstraffic.com/project/enabling-data-informed-decision-making-at-port/

	▶ iNode accurately assessed travel times and wait times with a 92% precision rate. ▶ iNode provided insights into traffic patterns and the routes taken by trucks. ▶ iNode furnished real-time truck locations within the port premises. **Environmental benefits:** ▶ Use of renewable energy sources for digital tools powering. ▶ Reduced emission of pollutants from road vehicles in the port and its immediate vicinity.

4.2 Port of Montreal – Trucking PORTal

Basic data	Description
Location of the port:	Montreal (Canada)
Inland waterway:	St. Lawrence
Category of digital tools:	Land traffic management system
Stakeholders involved:	Montreal Port Authority[34], Transport Canada[35], Centech[36], Merinio[37]
Description:	Port of Montreal is a port located in the St. Lawrence River, in the city of Montreal, Canada. It's situated 1,600 kilometres (1,000 miles) inland from the Atlantic and has a strategic location, providing access to some 100 million Canadian and American consumers.[38] Although not a typical inland waterway port by European standards, it is considered as both sea and inland port, due to the distance from the sea and due to the traffic with the Great Lakes waterway system on the one hand, and with the ocean lines on the other hand. St. Lawrence waterway's 15 locks (13 Canadian and 2 American) serve as the linchpin within the broader

[34] https://www.port-montreal.com/en/
[35] https://open.canada.ca/data/organization/tc
[36] https://centech.co/en/
[37] https://centech.co/en/startups/merinio/
[38] https://www.port-montreal.com/en/the-port-of-montreal/about-the-port

waterway, connecting the lower St. Lawrence River to the Great Lakes, enabling ships to transit between Montreal and Lake Erie, a difference in elevation of 168 metres.[39]

Applied digital tool: Trucking PORTal

The Truck PORTal is a free application in the service of road transport and the truck drivers who use the Port of Montreal. The PORTal provides real-time information on the traffic and waiting time at the port's international container terminals: Cast, Racine, Maisonneuve and Viau.[40] The main goal is to reduce greenhouse gas emissions per container through itinerary optimisation methods and to optimise the truck traffic in the port and its gates. A data collection system permits measuring the travel time of trucks from the entrance to the exit of the port and relays this information in real-time to the truck drivers and the dispatchers. The data aims to increase traffic fluidity in and out of the port, which saves trucking companies' time and money, while also reducing fuel use and greenhouse gases. Drivers can access the Trucking PORTal application online to help them better plan their schedule and routes. A predictive dashboard shows truckers the average processing times at the different terminals for each 30-minute period over the next 24 hours. Quick views are available for the following three hours. The system uses algorithms that factor in weather forecasts, the number of vessels expected and the average number of registered terminal visits to provide the necessary data and predictions.

The Trucking PORTal delivers info in real time on truck traffic and waiting times at the Cast, Racine, Maisonneuve (Termont) and Viau terminals in the Port of Montreal, which contributes to the shortening of the terminal waiting times. In addition, posting waiting times on the terminals allows the road transport industry and truck drivers to better plan their routes to terminal gates and reduce congestion at the entrance to the Port. Users of the application can create a profile and alerts that notify them when the waiting time reaches the level set by the users for each terminal. History of users' own waiting times at the terminals during their last truck trips to the port can be viewed.

The Trucking PORTal is part of the Port of Montreal's Greenhouse Gas Projects' that aims to reduce greenhouse gas (GHG) emissions. This project has received financial support from Transport Canada.

[39] https://greatlakes-seaway.com/en/the-seaway/
[40] https://www.initiativesrivers.org/vos-solutions/portail-camionnage-reduire-emissions-de-ges-ameliorer-mobilite-port-de-montreal/

Realised/potential impact	**Key impacts:** ▶ Reduced waiting time at the port/terminal gates ▶ Reduced congestion. ▶ Optimised truck traffic at the approaches to the port from the public road network. ▶ Gate performance increase of 15% without investments in new infrastructure.[41] **Environmental benefits**: ▶ Reduced emission of greenhouse gasses by 11% per ton of cargo handled.[42]

4.3 Port of Montreal – GALILEO Automated workforce management

Basic data	Description
Location of the port:	Montreal (Canada)
Inland waterway:	St. Lawrence
Category of digital tools:	Automated workforce management
Stakeholders involved:	Montreal Port Authority[43], Maritime Employers Association (MEA)[44], Airudi[45], Scale AI[46]
Description:	**Applied digital tool**: Galileo automated workforce management In collaboration with Airudi and with Scale AI's contribution, the Galileo tool is designed to enhance workforce dispatch planning at the Port of

[41] https://www.initiativesrivers.org/vos-solutions/portail-camionnage-reduire-emissions-de-ges-ameliorer-mobilite-port-de-montreal/
[42] https://www.portmtlcamions.com/en/about-the-trucking-portal/
[43] https://www.port-montreal.com/en/
[44] https://www.mea.ca/en/
[45] https://airudi.com/en/
[46] https://www.scaleai.ca

	Montréal. This artificial intelligence-powered solution improves supply chain visibility. It accurately predicts vessel arrivals 21 days in advance, in contrast to the current 24-hour predictability, enhancing overall performance and fluidity at the port. Galileo considers port traffic, weather, and cargo details to propose an optimal labour dispatch scenario, aligning with collective agreements and considering worker availability and classifications. Terminal operators gain an additional resource for informed decisions on labour needs. The Maritime Employers Association (MEA), managing longshore workers and checkers, recruits and deploys labour across multiple ports. Galileo aids terminal operators in optimal decision-making regarding workforce requirements. The tool addresses the challenge of unpredictable vessel schedules, allowing for better planning of training periods to maximise employee skills. With Galileo's AI-driven insights, the Port of Montréal gains visibility into the supply chain, facilitating accurate ship arrival predictions and promoting competitiveness in operational management. In essence, the improved visibility provided by Galileo benefits the entire supply chain ecosystem, enabling better handling planning across waterborne, road, and rail transport.[47]
Realised/potential impact	**Key impacts:** ▶ Reduced labour shortages. ▶ Optimised hiring costs. ▶ Minimised forecasting errors. ▶ Improvement of technical training programmes. ▶ Enhancement of coordination among stakeholders. ▶ Improved visibility of labour capacity. **Environmental benefits:** ▶ Reducing energy consumption and emissions associated with idle or inefficient processes.

[47] https://www.mea.ca/en/innovation/

4.4 Port of Haiphong – Smart Gate

Basic data	Description
Location of the port:	Haiphong, Vietnam (Hai Phong, Viet Nam)
Inland waterway:	Cam River
Category of digital tools:	Gate Operating System
Stakeholders involved:	Port of Hai Phong Joint Stock Co., Vietnam Maritime Corporation VIMC, Haiphong Department of Planning and Investment
Description:	Haiphong is an important port and industrial centre in North Vietnam, accounting for more than 90% of the entire cargo throughput of North Vietnam. The Port of Haiphong handles both maritime traffic and inland waterway traffic. Located on both banks of the Cam River, it belongs to the Haiphong waterway system which connects numerous provinces in the North and facilitates the transportation of nearly 40% of the total cargo volume moved by waterways in the North Vietnam. Today, Haiphong waterway system has more than 400 km of inland waterways with more than 50 inland waterway ports.[48] Haiphong is a national port complex consisting of 12 main ports and several smaller ports around the city. **Applied digital tools**: Smart Gate. Smart Gate is a Gate Operating System using the sensor system to control the gate access automatically upon the procedure completion. The identification system uses a series of image manipulation techniques to detect, normalise the image of the number plate, and then OCR to extract the alphanumerics of the container numbers and/or license plate numbers of tractors and trailers. Container and or truck identification can be done either automatically or by a gate officer scanning the relevant numbers or tags.[49] The recognised container numbers, truck license plates, and trailer license plates are cross-referenced with a database. This database contains information about approved shipments, authorised vehicles, and other relevant details. Based on the database verification, the gate operating system decides whether to grant or deny access. Approved vehicles proceed further into

[48] Yoon, D.-G., & Doan, T. B. T. (2018). A Study of the Logistics Development in Hai Phong Port. *Journal of Navigation and Port Research*, *42*(2), 137–142. https://doi.org/10.5394/KINPR.2018.42.2.137
[49] https://haiphongport.com.vn/en/sg/e-smart-gate

	the port, while any discrepancies or unauthorised access attempts trigger alerts. The use of sensors and automation improves the efficiency of the check-in / check-out process, reducing the time required for manual inspections. It also improves security by accurately verifying the identity of containers and vehicles entering or leaving the port. The system can also take and store photos captured from the outside of the container. It also sends relevant information via electronic display board at the gate and to the app (Container Driver) on truck drivers' phones. The system is fully integrated with the Terminal Operating System and the Container Checker application.
Realised/potential impact	**Key impacts:** ▶ Paperless and contactless transactions. ▶ Reduced waiting times at the gate. ▶ Congestion reduction. **Environmental benefits:** ▶ Lower emissions related to truck traffic and congestion.

4.5 Port of Haiphong – ePORT

Basic data	Description
Location of the port:	Haiphong, Vietnam (Hai Phong, Viet Nam)
Inland waterway:	Cam River
Category of digital tools:	Digitalised cargo management system
Stakeholders involved:	Port of Hai Phong Joint Stock Co., Vietnam Maritime Corporation VIMC, Haiphong Department of Planning and Investment
Description:	Haiphong is an important port and industrial centre in North Vietnam, accounting for more than 90% of the entire cargo throughput of North Vietnam. The Port of Haiphong handles both maritime traffic and inland waterway traffic. Located on both banks of the Cam River, it belongs to

	the Haiphong waterway system which connects numerous provinces in the North and facilitates the transportation of nearly 40% of the total cargo volume moved by waterways in the North Vietnam. Today, Haiphong waterway system has more than 400 km of inland waterways with more than 50 inland waterway ports.[50] Haiphong is a national port complex consisting of 12 main ports and several smaller ports around the city. **Applied digital tool**: ePort Electronic Port Service (ePort) is a web-based platform and has the main objectives to enhance service quality and implement information technology for improved delivery processes, electronic payments, and convenient services. This platform focuses on simplicity, speed, and convenience, aiming to reduce the need for customers to visit the port directly for transactions. This includes minimising the time spent on vehicle check-in procedures at port gates and alleviating traffic congestion within the port vicinity.[51] Services on e-Port include orders for taking raw materials, unloading goods, emptying containers, chemical inspection, closing and withdrawing containers, weighing orders, etc. Online payment methods consist of VNPay e-wallet, domestic ATM card in which the order system accepts both prompt payment and post-payment contracts. With this application, customers only need a phone with an internet connection, follow the instructions to complete the transaction in just 1-2 hours, and the staff does not have to go to the port. Thus, businesses can also reduce the number of employees on duty at the port for customs clearance. By the end of 2022, ePort services accounted for more than 30% of the total port throughput and revenue.[52]
Realised/potential impact	**Key impacts:** ▶ Increased efficiency and time savings due to paperless document exchange. ▶ Reduce of dwell times thanks to e-booking and e-payment services. ▶ Optimised labour. ▶ Reduced traffic congestion. **Environmental benefits:**

[50] Yoon, D.-G., & Doan, T. B. T. (2018). A Study of the Logistics Development in Hai Phong Port. *Journal of Navigation and Port Research*, *42*(2), 137–142. https://doi.org/10.5394/KINPR.2018.42.2.137
[51] https://haiphongport.com.vn/en/ep/e-port
[52] https://vccinews.com/news/47965/advancing-digital-transformation-in-seaport-industry.html

	▶ Lower energy and fuel consumption. ▶ Lower emission of traffic related pollutants.

4.6 Pangaon Inland Container Terminal – Online Vessel Billing System

Basic data	Description
Location of the port:	Pangaon, Bangladesh
Inland waterway:	Buriganga River
Category of digital tools:	Terminal Operating and Management System
Stakeholders involved:	Chittagong Port Authority (CPA), Bangladesh Inland Water Transport Authority (BIWTA), New Technology Systems Ltd. (NTS)
Description:	Bangladesh Inland Water Transport Authority (BIWTA) and the Chittagong Port Authority (CPA) jointly built and operate the Pangaon Inland Container Terminal (Pangaon ICT). The terminal to plays a positive role in the country's economic development by opening up a new horizon in the transportation of exported and imported goods through waterways. The project aims to help ease the pressure of cargo movement on the Dhaka-Chittagong railway and highway corridors. The terminal has a storage capacity of 3,500 TEU and handles 116,000 TEU annually. The capacity is planned to be raised, gradually, to 160,000 TEU. Three vessels – Pangaon Express, Pangaon Success and Pangaon Vision are employed to ship containers between the Chittagong seaport and Pangaon ICT. Each vessel can carry 128 TEU.[53] **Applied digital tool**: Online VBS (Vessel Billing System) Online vessel billing system streamlines the process of invoicing and billing for various services provided to vessels in a port. It also integrates billing processes with the management of shipping-related documents. The tools functions in the following way:

[53] https://pict.gov.bd/about/

- Users, including port authorities, shipping agents, and other stakeholders, register and log in to the online system.
- Details of vessels visiting the port, as well as relevant shipping information, are entered into the system. This includes vessel particulars, cargo details, shipping routes, and anticipated services.
- Users select the services required for each vessel visit, such as port dues, pilotage, berth occupancy, tug assistance, and more. The system calculates charges based on tariff rates, considering vessel specifications and service requirements.
- The system generates invoices detailing the costs associated with the selected services. Invoices may include a breakdown of charges, discounts, taxes, and any additional fees.
- An approval workflow involves relevant stakeholders reviewing and approving invoices. This ensures accuracy and compliance with regulations before the finalisation of billing.
- The system manages shipping-related documents, such as bills of lading, cargo manifests, certificates of origin, and other required paperwork. Users can upload, store, and retrieve documents within the system.
- Shipping documents can be submitted electronically through the system, reducing reliance on paper-based processes. This enhances efficiency and facilitates a better flow of information between stakeholders.
- The system may include features for document verification, ensuring that submitted documents meet regulatory requirements and comply with international shipping standards.
- Automated notifications and alerts keep stakeholders informed about the status of invoices, payments, and document processing. This ensures timely actions and reduces delays in vessel operations.
- The system facilitates various payment options for settling invoices, including online payment gateways, wire transfers, and other methods. Payment status is tracked and recorded.
- The system maintains a comprehensive record of all billing transactions, payments, and shipping documents. This recordkeeping supports auditing, compliance, and reporting requirements.

Realised/potential impact	**Key impacts:** ▶ Increased revenue collection. ▶ Time savings and reduction of complexity. ▶ Easy and user-friendly service to stakeholders. **Environmental benefits:** ▶ Reduced usage of paper documents. ▶ Faster turnaround time for vessels and consequent reduction of environmental footprint. ▶ Encouragement of sustainable practices through digital transformation.

4.7 Port of Wuhu – Blockchain document management system

Basic data	Description
Location of the port:	Wuhu, China
Inland waterway:	Qingyi River and Yangtze River (confluence)
Category of digital tools:	Blockchain-based shipping document management system
Stakeholders involved:	COSCO SHIPPING and Anhui Provincial Port & Shipping Group
Description:	Wuhu lies on the confluence of the Qingyi River and the Yangtze River in southeast Anhui Province. It is an important port and the junction of the Nanjing-Wuhu, Wuhu-Tongling, and Bengbu-Yuxikou railways. The city has iron and steel, machine building, electric power, shipbuilding, chemical, and light industries and heavily relies on the port for both bulk and container cargo handling. It is a major inland river port and a water/land intermodal hub of the province. It has a straight coastline, deep water and consists of two major port areas handling coal, general cargo, grain, ore, chemical fertilizers, containers and foreign trade. It has several port areas and different terminals. The Yuxikou port area handles coal and is the biggest on the Yangtze River, and it was the first

mechanised coal handling port facility among China's river ports. The Zhujiaqiao Foreign Trade Terminal integrates waterway, highway and rail transportation with the ability to handle a variety of different cargo. Traffic figures: Approx 14,750,000t of cargo handled annually. Load line zone: Summer. Max vessel draft is 6.5m, air draft 24m (during the dry season), while the flood season allows vessel draft of max draft 7.5m and air draught 21m. It can handle vessels of up to 10,000 DWT.[54]

Applied digital tool: Blockchain-based document management system

Since 2021, the Wuhu inland port has become the first inland port in China to realise blockchain-based paperless import cargo delivery. It represents a crucial undertaking by COSCO SHIPPING to proactively address the integration of the Yangtze River Delta, enhance strategic collaboration with Anhui Province, implement the Chinese Ministry of Transport's directives regarding the "clearway program" for port and shipping operations related to imported e-commerce cargo, and advance the digitalisation of the shipping sector.

The system is built on a blockchain infrastructure, a decentralised and distributed ledger that ensures transparency, security, and immutability of data. Port operators and shipping carriers interact through a blockchain-based application that enables real-time data exchange. This application serves as a platform for managing and sharing relevant information. Traditionally, the cargo clearance process involves multiple documents for identifying the consignee and shipping agent. A crucial document is the sea waybill/bill of lading, signifying the existence of a carriage contract between the shipper and carrier and serving as a receipt for the shipped goods. In the applied tool, registered users can access shipping documentation through the real-time updated cargo release application. This facilitates faster processing and reduced cargo release time. Additionally, the adoption of blockchain technology mitigates disruptions that might arise from the loss of sea waybills, crucial for cargo release at ports.[55] Leveraging the traceability and reliability features of blockchain, the system has achieved seamless data connectivity across diverse systems, fostering process collaboration and mutual trust between shipping companies and ports. This ensures visibility, time management, and risk prevention throughout the operational process. Previously, customers faced the challenge of multiple visits to complete the import business process involving shipping companies, ports, and other entities. With the current system, they can efficiently navigate all import delivery order (D/O) claim procedures online with a single click, reducing waiting times and travel

[54] https://shipnext.com/port/wuhu-cnwhi-chn
[55] https://blog.bcas.io/china_blockchain_updates

	costs. The paperless import cargo delivery system at Wuhu Port guarantees a seamless import business process for customers, expediting the unloading of substantial import containers. This not only attracts cross-border e-commerce import customers seeking timely services to opt for Wuhu Port but also addresses the container resource shortage for foreign trade exports in Anhui Province.[56]
Realised/potential impact	**Key impacts:** ▶ Significant gains on efficiency and speed of cargo clearance. ▶ Zero delay of import business for customers. ▶ Risk mitigation in terms of reduced errors and loss of paper documents ▶ Cost reduction for port operators and shipping carriers. ▶ Efficient use of container resources. ▶ Competitive advantage thanks to innovative technologies. ▶ Improved trade flows. **Environmental benefits:** ▶ Paper reduction. ▶ Reduced carbon footprint thanks to decreased waiting times for trucks and vessels. ▶ Efficient resource utilisation.

4.8 Port of Shanghai – Yangtze River intermodal platform

Basic data	Description
Location of the port:	Shanghai (and other connected ports along the Yangtze River: Taicang, Jiangyin, Nanjing, Jiuijang, Wuhan, Chongqing, Yibin, etc.), China
Inland waterway:	Yangtze River

[56] https://www.xindemarinenews.com/en/carrier/2021/0318/27993.html

Category of digital tools:	Information sharing platform
Stakeholders involved:	Shanghai International Port Group (SIPG), National Development and Reform Commission (NDRC),
Description:	The port of Shanghai covers an area of over 3,500 square kilometres at the mouth of the Yangtze River, the longest river in Asia. It consists of two main parts: a deep-sea port and a river port. The deep-sea port, also known as Yangshan Port, is located on reclaimed land in the East China Sea and is connected to the mainland by a 32-kilometer-long bridge. The river port, also known as Wusongkou Port, is located along the banks of the Huangpu River, which flows through the city of Shanghai.[57] Apart from the Port of Shanghai, many other Yangtze River ports are involved in a collaborative use of the digital tool herewith presented. **Applied digital tool**: Yangtze River container IWT-Sea intermodal transport service platform In 2018, Shanghai Harbor e-Logistics, a subsidiary of Shanghai International Port Group (SIPG), commissioned by the National Development and Reform Commission (NDRC), spearheaded the development and promotion of an integrated service platform for the intermodal transport service connecting the Yangtze River container transport and sea transport. This platform serves the diverse and dispersed ports along the Yangtze River, each with its distinct location and fragmented service offerings. It facilitates collaboration among ports, terminals, feeder line operators, shipping agencies, freight forwarders, and various service providers by enhancing information and resource sharing to optimise business operations. The platform's establishment aligns with the objectives of the Yangtze River Economic Belt Shipping Alliance, a collaborative effort initiated by nine port groups including Shanghai International Port Group (SIPG), Nanjing Port Group, and Jiujiang Port Group, as well as five shipping companies such as China Yangtze Shipping Group Company, Ltd., and Yangtze Port Logistics Company, Ltd. The overarching goal is to unlock the shipping potential of the Yangtze River Economic Belt through improved coordination and connectivity.[58] The platform also solves the data communication issues existing between many enterprises and users in the industry. Currently, this platform has consolidated all data of 17 midsize and large wharfs along

[57] https://silver-runner.com/shanghai-port-the-worlds-busiest-and-most-connected-port/
[58] The World Bank, 2020. "Accelerating Digitization: Critical Actions to Strengthen the Resilience of the Maritime Supply Chain." World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

	the backbone and trunk lines of the Yangtze River and implemented standardised data exchanges. The latest version — 2.0 — of this platform has added a new function of proactively pushing the shipping information to registered users, in contrast to the traditional approach where users had to log in to perform data queries. The application provides the following functions, among many others:[59] ▶ Sailing schedule query: Provides the departure plan for outbound containers, the sailing schedule applied for by the shipping agent, as well as berthing and unberthing plan for containers at the wharfs for the Port of Shanghai. ▶ Container and cargo query: Allows users to query information about containers, cargo, permitted release, pre-recorded information, plans, and others; provides information about containers at the wharfs along the Yangtze River enabled by the Port of Shanghai; and implements a complete tracking process. ▶ Verified Gross Mass (VGM) weighing information: Allows users to download the weight records of the Outbound Full (OF) containers at the wharfs of Shanghai's port. ▶ Permitted release information: Allows users to query the customs-permitting-release information sent EDI. ▶ Packing list pre-recording: Allows users to query the EDI pre-recording information about the packing list for OF containers.
Realised/potential impact	**Key impacts**: ▶ Enhanced collaboration and cooperation. ▶ Optimised business operation. ▶ Solved data communication issues. ▶ Improved visibility and tracking. ▶ Streamlined customs processes. **Environmental benefits:** ▶ Efficient resource utilisation. ▶ Reduced emissions due to minimised idle times of barges and trucks. ▶ Reduced paper use.

[59] https://e.huawei.com/en/ict-insights/global/ict-new-horizons-podcasts/Stories/shanghai-port

4.9 Port of Hefei – 5G technology for autonomous vehicles and cranes control

Basic data	Description
Location of the port:	Hefei, China
Inland waterway:	Nanfei River
Category of digital tools:	5G communication technology
Stakeholders involved:	Anhui Port Group Hefei Co., Ltd. and Anhui Provincial Port & Shipping Group
Description:	Hefei port is located in the Baohe Industrial Development Zone to the southeast of Hefei City, the provincial capital of Anhui Province, on the upper reaches of Nanfei River, with connections to the Yangzte River near Wuhu to the south. Hefei is one of nine big inland river ports of Anhui Province, and is capable of handling vessels up to 1,000 DWT. The port has four operational areas: Hefei New port, Cuozhen, Daxing and Shangpai with a total of 113 berths. The harbour area has an overall area of 328,600 m² including a water area of 200,000 m². The main cargoes handled in the port are bulk ore, iron and steel, timber, chemical fertiliser, coal, grain, edible oils, containers and manufactured goods for daily use. Traffic figures: Approx 8,737,200 t of cargo and 100,000TEU handled annually. Max vessel size: 1,000 DWT.[60] It is the most important international container port in central Anhui and northwestern Anhui, Fuyang, Henan Zhoukou, Xinyang, Luohe and other regions have important location advantages connecting the east to the west, connecting the Central Plains, and connecting the north and the south. It is also the largest inland container port on the tributary channel of the Yangtze River. **Applied digital tool**: 5G technology for autonomous vehicles and cranes control

[60] https://shipnext.com/port/hefei-cnhfe-chn

High speed and low latency 5G network is applied in order to provide seamless and real-time transfer of signals from the operating software to the automated or remotely operated cranes or container handling vehicles such as straddle carriers, reach stackers, etc. In combination with various IoT smart sensors distributed throughout the port, and using the Artificial Intelligence algorithms, the Terminal Operating System TOS controls the container handling equipment. In this case, when the TOS issues instructions, the unmanned container handling vehicle automatically travels to the designated position on the side of the ship, waits for the crane to put the container on the vehicle, and then go to the storage yard and stack it into stacks. This cycle goes on and on, and the whole process is completed in one go. Actions such as turning and parking are smooth and natural, and all are intelligently controlled by the operating system.

With advancements in science and technology, a select few coastal ports have undergone rapid transformation and upgrades in recent years by incorporating unmanned driving technology. However, the majority still relies on magnetic nails embedded in the ground for location sensing, a method entailing high investment costs and extended construction periods.

In contrast to the traditional approach, contemporary unmanned container handling vehicles no longer depend on magnetic nail induction for identification. This results in greater flexibility and adaptability in driving paths, coupled with enhanced accuracy in positioning. This shift signifies a pivotal step in port evolution, transitioning from a labour-intensive model to one characterized by technology intensity. The objective is to significantly make better the overall operational efficiency and service capabilities within the port, facilitating a more effective realisation of port production's intelligence and informatisation.[61]

In case of quay cranes, the reliability of 5G networks ensures consistent and uninterrupted data exchange, crucial for time-sensitive operations like crane automation. IoT sensors are embedded in various parts of the quay cranes to collect real-time data on performance, condition, surroundings, and environmental factors. The collected data is transmitted through the 5G network, allowing seamless communication between the crane and the central control system. AI algorithms analyse the vast amount of data generated by the IoT sensors. This includes crane movement patterns, equipment health, and environmental conditions. Big data technologies store and process the massive

[61] https://www.seetao.com/details/204780.html

	amounts of data generated by the IoT sensors and other sources. The combined data from IoT, AI, and big data is processed and managed through a centralised control system (Terminal Operating System).
Realised/potential impact	**Key impacts:** ▶ Efficiency improvement. ▶ Streamlined operations. ▶ Increased safety. **Environmental benefits:** ▶ Greener port operations thanks to the optimised movements. ▶ Reduced fuel consumption and thus reduced emissions. ▶ Energy efficiency.

4.10 Port of London – Maritime Emissions Portal

Basic data	Description
Location of the port:	London, United Kingdom of Great Britain and Northern Ireland
Inland waterway:	Thames
Category of digital tools:	Environmental monitoring tool
Stakeholders involved:	Port of London Authority (PLA), RightShip
Description:	Port of London is the largest UK port, and it covers 95 miles of the River Thames, from Teddington to the North Sea. It handles more than 50 million tonnes of cargo each year, supporting more than 40,000 jobs and contributing over £4 billion to the economy annually. Inland waterway transport' share reaches, in terms of annual throughput, over five million tonnes of goods and materials, and millions of passenger journeys. **Applied digital tool**: Maritime Emissions Portal (MEP)

	The user-friendly online tool equips ports with easily accessible emissions inventory data and analytical features for reporting and extracting information. This enables more informed management of local air quality. The MEP utilises the energy-based model for ship emissions in ports methodology, a distinctive vessel database, and, when integrated with the AIS, provides an estimate of emissions originating from ships. The emissions inventory encompasses GHG CO2e (CO_2, CH_4, N_20,) and air pollutants such as SOx, NOx, PM10, PM2.5, and VOC that are specifically linked to port activities. In order to realise this, a "target area" is first defined with clear boundaries ("geo-fenced"), such as port area, berth area, anchorage areas, transit areas, manoeuvring areas, etc. AIS data defines the vessel entry and exit from the port boundaries, together with detailed movement and vessel speed. AIS data is reported every three minutes while the ship is moving and every 20 minutes when stopped. The MEP platform uses AIS to track vessels entering the defined areas. A vessel call is determined by a ship entering and leaving the port boundary. During a call, each operating mode is calculated for each vessel and the vessel location data is also utilised to calculate speed. The AIS data is linked with RightShip's database to determine ship characteristics that are required for calculating emissions. Combining the AIS data and the platform provider's own database of vessels, the system generates a detailed emissions inventory of up to 16 different emissions against targets specified by the Port of London Authority.[62] MEP dashboards are then used to allow PLA to analyse reporting data by vessel type, area of interest or by pollutants.[63]
Realised/potential impact	**Key impacts:** ▶ Highlighting of problem areas with pinpoint accuracy, through heatmapping. ▶ Clear insights into vessel-based emissions and air quality in the port. ▶ Building trust with host communities by showcasing efforts to minimise the environmental impact of port operations. ▶ Easier and informed decision-making and adapting to changing circumstances. **Environmental benefits:**

[62] https://rightship.com/insights/rightship-and-port-london-authority-partner-support-maritime-decarbonisation
[63] https://rightship.com/technical-information?nid=108

	▶ Benchmark vessel-based emissions in the port, air quality performance, and tracking it over time. ▶ Ports are enabled to focus their efforts on specific zones for targeted emissions reduction initiatives. ▶ Measuring progress of environmental goals helping the port to achieve short, medium and long-term sustainability goals.

4.11 Port of Barranquilla – PEL Puerto en Linea

Basic data	Description
Location of the port:	Barranquilla, Colombia
Inland waterway:	Magdalena River
Category of digital tools:	Web platform
Stakeholders involved:	Puerto de Barranquilla, S.A.
Description:	Barranquilla is situated on the Caribbean coast, 10 nm upriver on the west (left) bank of the Magdalena River. It is the country's biggest Caribbean seaport, also having facilities for berthing, loading, and unloading of inland vessels carrying mostly general and bulk cargo. The port authority and private operators handle containers, breakbulk, liquid bulk and dry bulk cargo. The port includes the terminals of Monomeros, Gracetales, Vopak, Portmagdalena and SP Del Norte. Typical import cargoes handled in the port include rolled wire, steel, bulk grain, chemicals, project cargo, scrap metals, tuna fish, food products, vehicles, containers. On the other hand, the port serves as an export point for sugar, textiles, wood plates, tuna, synthetic fibres, steel and pharmaceutical products. Traffic figures: Approx 870 vessels, 3,326,400 t of cargo and 98,700 TEU handled annually.[64] **Applied digital tool**: Puerto en Linea PEL (Port on Line)

[64] https://shipnext.com/port/barranquilla-cobaq-col

The PEL is a comprehensive web-based solution designed to facilitate seamless communication and interaction among various stakeholders involved in port operations. Tailored to the specific needs of cargo owners, shipping agents, logistic companies, customs agents, and carriers, the PEL offers a range of functionalities that cater to different user roles and requirements.[65]

Key functionalities of the PEL:

- Loading orders. This platform segment is designed to handle loading orders efficiently. Users, including cargo owners and shipping agents, can input relevant information such as cargo type, quantity, and loading instructions.
- Bookings. The booking segment streamlines the process of scheduling cargo shipments. It allows users to make reservations, specifying details such as vessel preferences, cargo specifications, and preferred dates.
- Bill of Lading (B/L) release. This platform ensures smooth documentation flow. Users involved in the release process, such as shipping agents and carriers, can manage and authorise B/L releases securely.
- Loading/unloading orders and payments. The PEL efficiently manages loading and unloading orders, streamlining the process and providing a platform for handling related payments securely.
- Customs clearance processes. Addressing the complexity of customs procedures, the PEL aids in managing customs clearance processes efficiently, reducing delays and ensuring compliance.
- Shipping documents flow. The platform acts as a centralised hub for the entire shipping documents flow, ensuring that all necessary documents are processed, authorised, and accessible to relevant stakeholders.

Recognising the prevalence of general and bulk cargoes in inland navigation, the PEL includes specialised modules for these cargo types, providing tailored functionalities for handling their unique characteristics.

Stakeholders can input critical information, including vessel details, ETA/ETD, cargo specifics, and information on shippers and receivers. The platform supports various actions and authorisations, allowing users to participate in the workflow seamlessly.

[65] https://www.puertodebarranquilla.com/index.php/instructivos-pel/

	In summary, the PEL platform serves as a centralised and collaborative hub for the exchange of cargo-related information and the management of essential shipping processes. Its diverse segments cater to the specific needs of different stakeholders, ensuring a streamlined, transparent, and efficient flow of information throughout the entire port ecosystem.
Realised/potential impact	**Key impacts:** ▶ Streamlined communication and improved collaboration. ▶ Efficient information exchange. ▶ More visibility. ▶ Secure release of Bills of Lading ▶ Efficient customs clearance **Environmental benefits:** ▶ Reduced use of paper. ▶ Energy savings due to eliminated need to physically deliver documents. ▶ Reduced emissions due to less waiting times of vessels and vehicles.

4.12 Port Governance Agency of Serbia – PEP and Invoicing

Basic data	Description
Location of the port:	All ports in Serbia
Inland waterway:	Inland waterways network in Serbia: Rivers Danube, Sava, Tisa, and canals
Category of digital tools:	Digital reporting and invoicing platform
Stakeholders involved:	Port Governance Agency (PGA)
Description:	Port Governance Agency is a governmental organisation of the Republic of Serbia acting as a national port authority performing governance

functions over all inland ports in Serbia. PGA is not involved in operation of any port or terminal and performs its functions as a typical landlord port authority. Ports and terminals in Serbia are organised into 11 port areas, where the land is regulated as a public good (good of common interest). In each port area there are various port and terminal facilities operated by various independent port operators performing their functions on the basic on concession (long-term) or operating (short-term) contracts with the PGA. On the average, Serbian inland ports handle ca. 15 million tons of cargo annually, while the passenger traffic (cruises) reach ca. 200,000 passengers annually.

Applied digital tool: PEP and Invoicing

Electronic reporting portal (ERP or PEP) allows users (vessel operators and cargo owners, or their agents acting on their behalf) to report the usage of a port in a paperless form. The portal enables the following functions:

- Provide a user-friendly registration process for different stakeholders, including shipping companies, cargo owners, agents, and other service providers.
- Implement secure authentication mechanisms to ensure the confidentiality and integrity of user data.
- Enable users to manage and customise their profiles, including contact details, preferences, and notification settings.
- Allow shipping companies to report vessel arrivals and departures, providing essential details such as vessel name, type, tonnage, and purpose of visit.
- Enable cargo owners to report details about incoming and outgoing cargo, including type, quantity, and other relevant information.
- Enable online payment functionalities for port-related services, including port dues, berth fees, and other charges.
- Provide transparent invoicing and financial reporting.
- Offer data analytics tools to generate reports and insights based on the information submitted by port users.
- Provide customisable reporting features for different stakeholders to meet their specific needs.
- Implement robust security measures to safeguard sensitive data and ensure compliance with data protection regulations.

	▶ Regularly update the portal to address security vulnerabilities and maintain a secure operating environment. Typical input data required by the PEP are: Bill of Lading, Cargo Manifest, Customs documents, quantity and type of cargo loaded/unloaded, loading/unloading commencement/completion times, etc. The system cannot be used for advanced planning as the information are entered "post-festum", maximum 24 hours after a vessel leaves the port. The portal allows limited data analytics functions, but without any forecasting capabilities. Accompanied invoicing application creates invoices to the port users, on the basis of data introduced in the PEP. Since the PEP and the invoicing application are not directly interoperable, the linking application (middleware Robotic Process Automation – RPA) "translates" the data from the PEP into the invoicing application, thus enabling the creation of invoices to the relevant users.
Realised/potential impact	**Key impacts:** ▶ Time an efficiency gains. ▶ Enhanced communication. ▶ Streamlined information exchange. ▶ Improved collaboration. **Environmental benefits:** ▶ Reduced paper usage. ▶ Lower energy consumption due to faster and more efficient processes. ▶ Reduced emissions thanks to the reduced physical distribution of documents.

05

Conclusions

5.0 Conclusions

To conclude, several key conclusions can be drawn along with some overarching themes and key takeaways based on this analysis.

5.1 Operational and efficiency gains

Across the globe, inland ports have significant operational and efficiency gains through digitalisation initiatives. From streamlined cargo handling processes to improved supply chain visibility, digital tools have empowered port operators to optimise their operations and improve overall efficiency. Examples such as online reporting systems in the Port of Györ-Gönyü, vehicle booking platforms in Antwerp and Montreal, and port management and information system in Strasbourg, showcase the breadth and depth of digital solutions employed to improve operational performance.

5.2 Environmental benefits

Crucially, identified good practices demonstrated the profound environmental benefits of inland port digitalisation. Implementation of advanced technologies such as IoT sensors, artificial intelligence, and blockchain, enabled ports to minimise environmental impact, reduce emissions, and promote sustainability throughout their operations. Environmental benefits have been achieved in almost all cases where digital tools have been implemented, but the most direct one were the ones where either vessel or truck management systems were deployed, such as in HAROPA ports, or ports of Montreal and Antwerp. From energy-efficient logistics to eco-friendly infrastructure management, inland port digitalisation proved itself as a potent catalyst for environmental stewardship, paving the way towards a greener and more sustainable future for inland ports.

5.3 Common elements and key takeaways

Despite the diversity of approaches and contexts from one country to another, several common elements unite the good practice cases identified in this report. These include:

- A commitment to deployment of digital technologies to improve operational efficiency, economic competitiveness, and environmental sustainability.
- Strategic collaboration among port stakeholders, local authorities, and industry partners can drive digital innovation and foster a culture of continuous improvement along with the awareness of environmental benefits resulting from optimal movements of vessels, vehicles and cargo thanks to digitalisation.

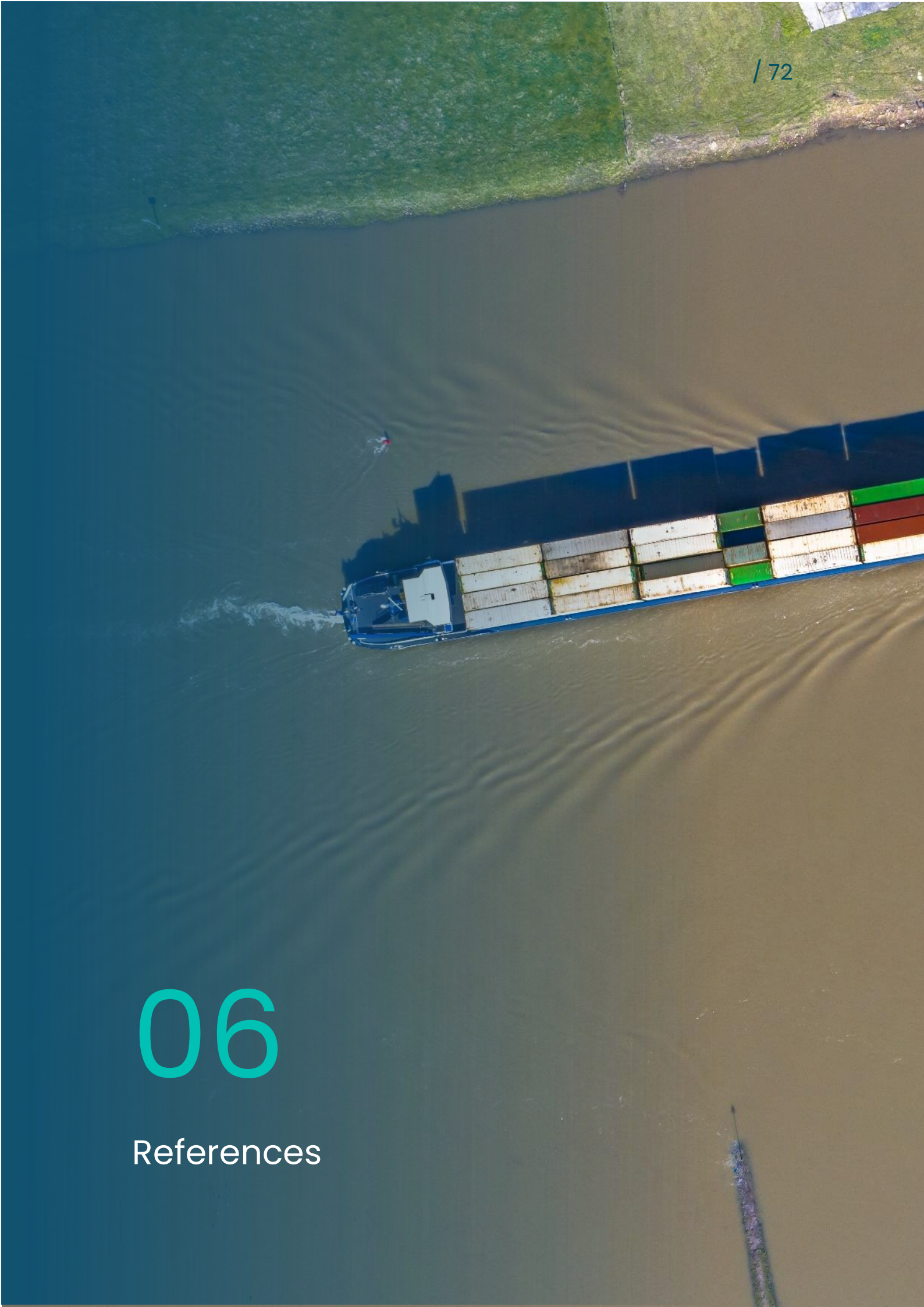
- A phased approach to digitalisation is clearly visible amongst the port analysed in this report, with ports starting with simple digital tools (e.g. Serbian ports, ports of Barranquilla and Győr-Gönyü) and gradually scaling up to more advanced solutions as they mature in their digital journey and as they gain in knowledge and experience (e.g. ports of Montreal, Trier, HAROPA or Strasbourg).
- It is clearly visible that all ports have placed an emphasis on data-driven decision-making and predictive analytics to optimise resource allocation, enhance risk management, and improve overall performance.
- A focus on interoperability and data exchange standards to facilitate seamless integration of digital systems (such as in the ports of Antwerp or Haiphong) and promote greater efficiency and transparency across the port ecosystem.

5.4 Main messages

Several main messages can be identified here:

- Digitalisation is not only a technological endeavour but a strategic imperative for inland ports looking to thrive in an increasingly competitive landscape.
- Environmental sustainability should be at the forefront of digitalisation efforts, with ports leveraging digital tools to minimise their ecological footprint and contribute to the goals of the European Green Deal and the Sustainable and Smart Mobility Strategy, as well as global efforts towards climate resilience and resource conservation.
- Collaboration, innovation, and adaptability are key to success in the digital era, with ports embracing a culture of openness, experimentation, and continuous learning to stay ahead of the curve.
- The journey towards digitalisation is ongoing, requiring a long-term commitment, strategic vision, and proactive engagement from all stakeholders involved.

In closing, the good practice cases presented in this report are useful for guidance for inland ports on their digitalisation journey or seeking to expand their level of digital maturity. Undertaking necessary measures towards digitalisation, fostering strategic partnerships, and prioritising environmental sustainability, can lead to new opportunities for inland ports.



06

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