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Study on Enabling Sustainable Management and Development of inland ports

D3.4 Gaps and barriers in the development and implementation of digital tools

Rotterdam, 24 09 2024

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Zwijndrecht, 24-09-2024

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Summary

The objective of this report is to look at gaps and barriers affecting the development and implementation of digital tools and applications at port administration/authority level and at port community level across the several stakeholders involved. To do so, an analysis was made consisting of a desk research coupled with a thorough literature review, a survey with over 30 responses and a small number of interviews targeting expert interviewees representing multiple inland ports.

Perhaps the most clear result from the analysis was the abundance of organisational barriers inland port managers face in some cases. Especially smaller ports under management by smaller municipalities often were managed in a fragmented way. I.e. there is no central municipal body that manages all port-related aspects, all these responsibilities are spread out over multiple municipal divisions. Coincidentally, employees working on these responsibilities often have other areas of responsibility as well and are thus not able to specialise in port management only. This is a clear organisational barrier affecting the effectiveness of the workforce.

Hand in hand with the barrier above often comes a lack of available budget for port operations, let alone digitalisation. This lack has two grounds: sometimes municipalities just lack budget as a whole which is an issue in itself, but other cases clearly show that the importance of a local inland port is not always understood by local policy makers and politicians. The latter leads to less municipal attention and budget for port management and can also contribute to the fragmentation of port management responsibilities.

There are however many other barriers and gaps that stand between European inland ports and (further) uptake of digital tools and applications. Digitalising this sector will be challenging because of the generally low level of standardisation, interoperability problems between the systems currently in use, a fragmented and not fully covering legal framework, and a shortage of qualified staff to implement the necessary changes.

Analysis of the gaps and barriers found clearly showed their spread over the areas legal, financial, technical and workforce. The gaps and barriers per theme are discussed in more detail in the chapter 4 “gaps and barriers”, but hereunder the most important ones are summarized.

Legal

- Fragmentation of the legal framework: hard to navigate;
- No legal standardisation of systems to use: plethora of systems in use;
- Clear gaps in the legal framework regarding liability issues: no coverage of cyber security legislation for inland ports;
- Overall liability challenges: unclear, no standardised solution;
- Data security regulations are a barrier for data sharing: harder to implement some digital innovations;
- No rule-out of the non-digital option: systems and personnel to service non-digital way of operation cannot be removed. Costs cannot be saved.

Financial

- Lack in available budgets for managing inland ports, and thus for digitalisation: due to a lack of understanding of local policymakers and politicians regarding the benefits of inland ports;

- Organisational fragmentation: due to the same issues as the bullet above, co-resulting in budget issues and unclarity;
- Subsidy framework is unclear and not always easily navigable.

Technical

- Port management needs for greening/modernisation not yet fully covered;
- Lack of standardisation in systems: reduced interoperability;
- Age of systems in place: not always suitable for interoperability with more innovative systems;
- Data quality is an issue: e.g. emissions monitoring is hampered by this;
- Regional non-harmony: differences in digitalisation 'level' between regions, difficult to standardise or navigate for region-crossing operators;
- Manual data input still in use: reduction in efficiency of systems and increased risk of human error;
- Cyber security is an ongoing area of concern: solutions require continuing attention and budget.

Workforce

- Capacity in the workforce is a gap: not enough skilled personnel available for all port management and digitalisation needs;
- Barriers such as cyber security, legal barriers and others mentioned above only increase the skill-level needed by the workforce;
- Organisational gaps: often there is no single port division but a fragmentation of port related responsibilities over multiple divisions;
- Organisational gaps: (related to the above) staff is often not port-specialised but has many other areas of responsibility.

List of abbreviations

AI - Artificial Intelligence
AMS - Asset Management Systems
AR - Augmented Reality
EMTs - Environmental Management Tools
IoT - Internet of Things
IWT - Inland Waterway Transport
PCS - Port Community Systems
PMS - Port Management Systems
TOS - Terminal Operating Systems
VR - Virtual Reality

1 Introduction

Sub-task 3.4: Gaps and barriers in the development and implementation of digital tools has as its objective to look at gaps and barriers affecting the development and implementation of digital tools. Over the past few decades, digital technologies have been spreading at a reasonably fast pace. However, many inland ports are not fully digitalized yet and or want to digitalize further than they currently have accomplished. Many obstacles seem to hamper the wider adoption and effective use of digital technologies by inland ports and -terminals.

The third task of Green Inland Ports has as its goal to draft a roadmap for the furthering of digitalisation within inland ports. To do so, it is critical that gaps and barriers regarding digitalisation are identified. This report attempts to do so.

By using a combination of interviews, desk research and a survey, sub task partners have been working to identify as many gaps and barriers as possible. The survey was circulated in the wider EU inland ports community, attracting responses from across Europe. Interviews were targeted at inland ports and/or their representatives to delve deeper into the details of their digitalisation efforts. Desk research has focussed on the analysis of existing literature, including reports from past projects (were, sometimes, one or more sub task members were involved), to extract the lessons learned from past research on this heavily researched topic.

Gaps and barriers will thus be extracted from sources mentioned above and will be clustered and analysed according to four categories: legal, financial, technical/functional, HR/Workforce related. The task statement of this sub-task is copied below for clarity:

Sub-task 3.4: Gaps and barriers in the development and implementation of digital tools
The objective of this sub-task is to look at gaps and barriers affecting the development and implementation of digital tools and applications at port administration/authority level and at port community level across the several stakeholders involved.

Digital technologies have been spreading rapidly, but many obstacles still hamper their wider adoption and effective use by inland ports and terminals. Significant differences still persist between advanced and emerging economies, which translates also to the case of the inland ports sector. The COVID-19 pandemic has pushed many ports lagging behind the digitalisation trend to accelerate the implementation of a range of measures to support digital transformation and the adoption of digital tools among which, improving the broadband connectivity, promoting online payments and enhancing digital skills of employees. An analytical research method will be used to develop a ready-to-use method in the form of a survey that can be applied to measure the overall gaps and barriers and identify problem areas. The survey will be circulated in the wider EU inland ports community and beyond. Complementary, interviews will be organised. Gaps and barriers will be clustered and analysed by categories such as: legal, financial, technical, functional and workforce related.

2 Literature review

The literature review of this report has been written to ensure that no key messages from relevant earlier work are missed and to establish a knowledge base for sub-task 3.4. The literature review as presented hereunder heavily focuses on earlier work in GRIP Task 3 since these results are of key importance to identify gaps and barriers for inland port digitalisation. Literature outside of the GRIP project was also assessed, focusing on relevant projects such as DIWA Masterplan[1] and PLATINA3[2]. For readability reasons this part of the literature review was directly translated into the desk research results as presented in the next chapter, section 3.3.

2.1 Digital tools

2.1.1 Introduction

Digital tools refer to software, applications, and systems that leverage digital technologies to improve efficiency, accuracy, and connectivity in various processes. In the context of inland ports, digital tools can enhance operations, reporting, and environmental management. In 2.1.2 some of the digital tools available and commonly used in present inland ports are introduced. Next, 2.1.3 discusses the usage and prevalence of digital tools. Then, in 2.1.4 the gaps and barriers in implementing digital tools are identified.

Deliverable D3.2 of the Green Inland Ports study focuses on the inventory of digital tools and applications used in inland ports, aiming to evaluate their impact on greening and economic sustainability. The document highlights the essential role of digitalisation in enhancing port operations, environmental management, and overall efficiency.[3] Although the document is a deliverable in the same task, it is of vital importance to understand its outcomes and therefore these are summarised below in 2.1.2 – 2.1.5.

2.1.2 Types of digital tools identified

The deliverable categorizes digital tools into several key areas:

1. **Sensors and devices**: These form the foundational elements of port digitalisation, facilitating (real-time) monitoring and data collection across various port operations.
2. **Advanced digital technologies**: These include the Internet of Things (IoT), Blockchain, Big Data Analytics, Artificial Intelligence (AI), and 5G networks. These technologies enable predictive maintenance, optimize cargo handling, and improve traffic management.
3. **Simulation technologies**: Virtual Reality (VR) and Augmented Reality (AR) are employed for training, port design, and security enhancements. Digital Twins provide real-time data analysis, offering insights into port operations and facilitating proactive decision-making.
4. **Software platforms**: Port Community Systems (PCS), Terminal Operating Systems (TOS), and Port Management Systems (PMS) are crucial for efficient port operations. These platforms streamline processes, improve communication, and support environmental reporting and performance measurement.
5. **Port automation and autonomation**: Cargo handling automation and autonomous systems (including drones) improve operational efficiency and reduce human error. This category distinguishes between digitalisation (use of digital tools) and automation (use of automated systems).

[1] DIWA: https://www.masterplandiwa.eu/

[2] PLATINA3: https://platina3.eu/

[3] GRIP D3.2 Inventory of port cooperation and collaboration systems, digital tools and applications and assessing their effect on greening and economic sustainability objectives

2.1.3 Usage and prevalence of digital tools

The deliverable reports high awareness and adoption of digital tools among inland ports. Many ports have established digitalisation strategies, as standalone documents or integrated into broader development strategies. Key findings from the survey include:

- **Common digital tools**: Terminal Planning and Operating Systems (TOS) and reporting applications are widely used, with over half of the surveyed ports implementing these tools. Port Management Systems (PMS) and predictive maintenance systems are also prevalent.
- **Environmental Management Tools (EMTs)**: Despite the benefits, usage of digital environmental management tools is relatively low, with only 7.7% of ports reporting their use. Environmental Management Tools supports inland ports in meeting environmental objectives efficiently, complying with regulations, and contributing to sustainable and responsible port management

2.1.4 Gaps and barriers in digital tool implementation

Several challenges and barriers to the effective implementation of digital tools in inland ports were identified[4]:

1. **High costs**: The initial investment in digital infrastructure and technologies can be prohibitive for some ports. Smaller ports often lack the necessary resources to invest in digitalisation. They handle smaller cargo volumes, making significant investments in digital tools less justifiable in the short term. Smaller ports and companies might fall behind in digital development due to limited resources, potentially leading to inequalities in the logistics chain where only larger entities benefit from digital advancements.
2. **Skilled workforce**: There is a need for a workforce skilled in managing and operating digital systems. Training and development are crucial for successful digitalisation. Digitalisation projects require specialized skills and resources for the planning, implementation, and operation phases.
3. **Cyber security concerns**: Digitalisation increases the risk of cyber threats, with concerns around information security, cloud-service reliability, intellectual property rights, and copyright agreements being major issues. Cyber security is identified as a critical development area necessary for building trust in digital systems. Robust cyber security measures are essential to protect sensitive data and operations. Ports need regular updates to their cyber security plans to mitigate risks effectively.
4. **Interoperability and standardization**: Ensuring that different digital systems and tools can work together seamlessly is a significant challenge. Different stakeholders use various service providers and equipment, leading to compatibility issues and operational bottlenecks due to the lack of information sharing. There are challenges related to data exchange between different operator systems, which are not necessarily compatible. Standardized data formats and protocols are necessary for effective integration.
5. **Regulatory compliance**: Ports must navigate various environmental and operational regulations, which can complicate the adoption of new technologies. More about regulatory compliance in the next section.
6. **Resistance to change**: There is resistance from ports and logistics companies to share data unless it is mandatory. This limits the potential benefits of digitalisation. Also, a general lack of information about the benefits and solutions provided by digitalisation among stakeholders contributes to resistance and slow adoption.
7. **Strategic vision and planning**: The initial phase of digitalisation is critical. Wrong decisions or solutions can lead to extensive costs and losses if not planned strategically. A clear vision

[4] Brunila, OP., Kunnaala-Hyrkki, V. & Inkinen, T. Hindrances in port digitalisation? Identifying problems in adoption and implementation. *Eur. Transp. Res. Rev.* **13**, 62 (2021). https://doi.org/10.1186/s12544-021-00523-0

and long-term planning are essential to avoid these pitfalls. Adopting a modular approach allows for flexibility and future expansion, but if digitalisation is treated as a one-time project, it can limit future growth and adaptability.

2.1.5 Conclusion

Implementing digital tools in inland ports enhances efficiency, accuracy, and environmental management. Various categories of digital tools have been identified, including sensors, advanced technologies, simulation tools, and software platforms, all of which offer significant benefits such as real-time monitoring, predictive maintenance, and improved communication and reporting systems. Despite widespread awareness and adoption of these tools, the use of digital environmental management tools remains relatively low, highlighting an area for potential growth.

However, several challenges hinder the effective implementation of digital tools. Major barriers are high costs, a lack of skilled workforce, cyber security concerns, interoperability issues, regulatory compliance, resistance to change, and the need for strategic vision and planning. Smaller ports, in particular, struggle with limited resources, leading to disparities in the logistics chain. Addressing these challenges through strategic planning, investment in training, and robust cyber security measures is essential. By embracing the benefits of digitalisation and overcoming these barriers, inland ports can significantly improve their operational efficiency, environmental performance, and economic sustainability.

2.2 Relevant legislation

2.2.1 Introduction

The digitalisation of ports is accompanied by a complex legal framework within the European Union that governs crucial aspects of data management, cyber security, and liability (and more). This section 2.2 explores the legal framework and its gaps and barriers for the ongoing digitalisation efforts in European ports. This section reviews the results of GRIP sub-task 3.1.[5]

2.2.2 Legal framework

The legal framework for port digitalisation consists of general acts applicable to port digitization processes. The EU has a distinct legal order and is therefore not part of national or international law, which is relevant for its application and enforcement.[6] The EU legislator has two main instruments: Regulations and Directives.

- **Regulations**: Directly applicable in all Member States without transposition. They ensure uniform application across the EU.
- **Directives**: Require transposition by Member States into their national law, allowing some discretion in implementing the directive. This flexibility can lead to differences in national implementations, which are not considered imperfections but inherent consequences of the choice for a Directive instead of a Regulation. The discretion varies based on whether the Directive provides for (1) minimum harmonization (allowing stricter national rules) or (2) maximum harmonization (prohibiting stricter national rules).

The following relevant EU legislation will be explained: (1) privacy (GDPR), (2) data ownership/rights, (3) cyber security, and (4) liability for defective software.

1. **Privacy – GDPR (General Data Protection Regulation)**

Regulation (EU) 2016/679, known as the General Data Protection Regulation (GDPR), protects the personal data of individuals. The GDPR is a cornerstone of EU data protection law and has

[5] GRIP D3.1 Regulatory framework addressing inland ports digitalisation

[6] https://europadecentraal.nl/onderwerp/europese-unie/decentrale-overheden/rechtstreekse-werking/

considerable implications for port digitalisation efforts. While port operations might seem primarily focused on cargo and vessels, the GDPR's broad definition of personal data means it can apply to various aspects of port digitalisation:

- **Personal data** in port call systems (e.g., captain or crew information)
- **Employee data** in workforce management systems
- **Customer data** in logistics or booking platforms

The GDPR mandates (among other things) that:

- **Data controllers** must obtain consent to use data or have a legitimate reason for processing personal data. Personal data means *any* information relating to an identified *or identifiable* natural person (Art. 4.1). An 'identifiable' natural person is a person who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.
- **Fundamental principles** (Art. 5) **and rights and obligations** for data controllers and subjects must be observed.
- If a smart port application does indeed process personal data, the data 'controller', i.e. the entity that determines the purposes and means of the processing of personal data, must either obtain the **consent** of each 'data subject' or be able to invoke one of the allowed **reasons** for processing personal data (Art. 6.1).

Ports, shipowners, and technology providers must ensure GDPR compliance in all their digital tools. They must implement data protection by design and default, conduct data protection impact assessments where necessary, and have proper data processing agreements.[7]

2. Data ownership (data rights)

As digitalisation progresses, questions about data sharing and ownership arise. Data in many legal systems cannot be 'owned' in a strict (material) sense. Instead, the focus is on data *rights*. Several legal instruments address data usage and sharing. Contracts can specify data-sharing rights and conditions, but they have limitations, such as the need for alignment across different contracts and the risk of clauses being deemed unfair by courts.

The EU Commission is well aware of the importance of data and data sharing for technological and economic progress. In February 2020, the Commission presented 'A European Strategy for Data', setting out a vision to create a European Data Space. The EU has implemented several initiatives to address data sharing:

- **Directive (EU) 2019/1024 on open data and re-use of public sector information**: Replaces Directive 2003/98/EC, it applies to 'open' data held by public bodies, excluding data protected by third-party IP rights, commercial confidentiality, or personal data.[8]
- **Data Governance Act (Regulation (EU) 2022/868)**: Establishes rules for the re-use of data held by public sector bodies that are protected due to commercial confidentiality, statistical confidentiality, IP rights, or personal data reasons.[9]
- **Proposed Data Act**: Focuses on data generated by IoT products, defining user rights to access and share this data. It complements the existing obligations like the European Maritime Single Window environment for seaports, the Directive on Intelligent Transport Systems (ITS) for road transport, and the Directive on River Information Systems (RIS) for inland shipping. The proposed Data Act would primarily determine which rights the users of such products have regarding the data collected or generated by those products, including for example the right to demand that the manufacturers of those products allow access to

[7] Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data.

[8] Directive (EU) 2019/1024 on open data and the re-use of public sector information

[9] Regulation (EU) 2022/868 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act).

the data or forward the data to third parties. Such third parties could for example be the developers or operators of port digitalisation systems.[10]

3. **Cyber security**

Digitalisation increases vulnerability to cyberattacks, making robust cyber security measures essential. Relevant European legislation includes:

- **The Cyber security Directive (EU 2022/2555)** imposes obligations on the Member States (for example to adopt a national cyber security strategy and to designate a competent authority) but also on the management bodies of 'essential and important entities' (Chapter IV, Articles 20-25). This Directive (currently) only applies to maritime ports, not to pure in-land ports.[11]
- **NIS (Network and Information Systems) Directive (EU) 2016/1148):** Requires Member States to ensure high common security standards for network and information systems. This directive emphasizes the importance of protecting digital infrastructure against cyber threats.[12]

4. **Liability for defective software**

Digital port tools can cause damage if they produce incorrect results. The liability for such defects depends on whether the software is bespoke or off-the-shelf:

- **Bespoke software**: Developed based on customer specifications, liability depends on the developer's adherence to professional standards.
- **Off-the-shelf software**: Expected to meet the reasonable expectations of the average user. Liability arises if the software contains unreasonable bugs or lacks expected functionalities.

Relevant European legislation includes:

- The proposed **AI Act** and the **Directive on non-contractual liability resulting from using AI systems** address issues specific to AI applications, which many smart port tools would fall under. The AI Act broadly defines AI systems and sets out principles for liability, including fault and causal link presumptions.[13]
- **The Digital Services Act** (EU 2022/2065) imposes rules on entities that provide intermediary services for 'information society services'.[14]
- **The Digital Markets Act** (EU 2022/1925) regulates the position of 'gatekeepers', i.e. businesses providing certain digital services that significantly impact the internal market and have a strong position. The providers of smart port tools will generally fall outside the scope of these Acts.[15]

2.2.3 Gaps and barriers in relevant legislation

The following gaps and barriers will be discussed: regulatory fragmentation, data sharing issues, liability issues, cyber security risks, balancing innovation and regulation, standard contracts, scope and applicability uncertainties, cross-border challenges, and skills and resource gaps.

Regulatory fragmentation (legal and regulatory framework)

[10] Proposal for a Regulation on harmonized rules on fair access to and use of data (Data Act), COM(2022) 68 final.
[11] Directive (EU) 2022/2555 of 14 December 2022 on measures for a high common level of cyber security across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive).
[12] Directive (EU) 2016/1148 concerning measures for a high common level of security of network and information systems across the Union (NIS).
[13] Proposal for a Directive on adapting non-contractual civil liability rules to artificial intelli-gence (AI Liability Directive), COM(2022) 496 final.
[14] Regulation (EU) 2022/2065 on a Single Market For Digital Services and amending Directive 2000/31/EC (Digital Services Act).
[15] Regulation (EU) 2022/1925 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act).

There is no specific European (or international) legislation dedicated to the digitalisation of ports. The relevant legal framework is spread across multiple directives and regulations, some still in the proposal stage. This fragmentation can make compliance challenging and costly, especially for smaller ports or technology providers. It may also lead to inconsistencies in implementation across different EU member states. The existing legal framework consists of more general acts that may apply to port digitalisation efforts, creating a complex regulatory environment. This framework includes various regulations and directives, each with its scope and limitations.

The broad definitions in some legislation (e.g., the AI Act) create uncertainty about which port technologies might be subject to new regulations. This uncertainty can make it difficult for ports to plan and implement long-term digitalisation strategies.

Data sharing issues

Digital tools require extensive data sharing between stakeholders, including port authorities, shipping companies, and logistics providers. Ports must navigate the balance between data protection and leveraging data for improved operations. Data sharing is restricted by several issues:

- **Legal restrictions**: Regulations like the GDPR limits data sharing to protect privacy and personal data. GDPR requirements can sometimes conflict with efforts to increase data sharing and operational efficiency
- **Data sensitivity**: The Open Data Directive and Data Governance Act distinguish between open and sensitive data, complicating the availability of necessary information.
- **Reluctance to share**: Stakeholders may be unwilling to share data concerning data misuse, competitive advantage, or liability.

Liability issues

The liability framework for digital tools in ports remains unclear, especially for AI systems. The adoption of digital tools introduces new liability concerns:

- **Defective software**: Digital tools can produce incorrect results, leading to potential claims for losses or damages. The liability for such defects depends on the contractual arrangements between parties. Questions remain about responsibility for data accuracy, system failures, or decisions made based on algorithmic recommendations
- **Non-contractual liability**: Proposed AI regulations address liability for AI systems, but these rules are complex and still evolving. Determining fault and proving the causation of damage caused by digital tools, remains a challenge. The complex ecosystem of port stakeholders (authorities, terminal operators, shipping lines, etc.) further complicates liability issues

Cyber security risks

Ports are critical infrastructure and thus attractive targets for cyberattacks. Ports are susceptible to attacks that could disrupt operations or compromise sensitive data. Cyber security needs to be integral to the design of digital tools, not an afterthought. The Cyber security Directive (NIS 2) currently applies only to maritime ports, not inland ports, leaving a regulatory gap for cyber security measures in inland navigation. As ports become more digitalized and interconnected, ensuring comprehensive cyber security becomes increasingly important.

Balancing innovation and regulation

While regulation aims to protect rights and ensure safety, overly restrictive rules could stifle innovation in port digitalisation. Finding the right balance between enabling new technologies and managing risks is an ongoing challenge.

Standard contracts

While standardized contracts for data input and output could help, they require widespread acceptance and adherence by all parties involved.

Cross-border challenges

Ports often deal with international traffic, creating complexities in applying EU regulations to non-EU entities. Ensuring consistent application of digital standards and regulations across different jurisdictions remains a challenge.

Skills and resource gaps

Complying with complex and evolving regulations requires specialized knowledge and resources. Smaller ports or stakeholders may struggle to keep up with regulatory requirements, potentially widening the digital divide in the sector.

2.2.4 Conclusion

In conclusion, while the digitalisation of ports promises substantial benefits, navigating the intricate legal framework within the EU presents challenges. Addressing regulatory fragmentation, enhancing data sharing frameworks, clarifying liability regimes, fortifying cyber security measures, and fostering innovation while ensuring compliance are essential steps toward achieving a harmonized, secure, and efficient digital future for European ports.

2.3 Technical developments

2.3.1 Introduction

This chapter delves into the current technical developments in port digitalisation, focusing on European and global practices. It also identifies gaps and barriers in adopting and implementing digital tools, providing insights derived from ongoing projects and case studies. The results of GRIP deliverables D3.3[16] and D3.5[17] were used as basis for this section 2.3.

2.3.2 Technical developments in the digitalisation of ports

Port management

The digital transformation of port management is a key area where advancements are made. Ports are increasingly adopting digital tools to streamline various administrative and operational processes. For instance, asset management systems enable ports to efficiently manage and maintain infrastructure and cargo-handling equipment. These systems range from basic digital records to sophisticated IoT-based tools allowing for proactive tracking and maintenance scheduling. For example, the Posidonia Operations system at the Port of Sevilla centralizes information on vessel movements, automating workflows and improving coordination among stakeholders.[18]

Port Community Systems (PCS)

Port Community Systems (PCS) facilitate seamless information exchange among various stakeholders, including shipping lines, terminal operators, and customs authorities. The Ci5 PCS in the Ports of Rhône exemplifies how these systems improve operational efficiency by streamlining communication and data sharing. PCS enhances transparency, reduces paperwork, and accelerates cargo handling processes by providing a unified platform for managing port logistics.[19]

[16] GRIP D3.3 Catalogue of upcoming projects, tools, and technologies supporting enhanced interoperability and analysis of process optimization perspectives

[17] GRIP D3.5 Inventory of good practices at the EU and international level

[18] GRIP D3.5 2.1 Port of Sevilla – Posidonia Operations

[19] GRIP D3.5 2.5 Ports of Rhône – Ci5 Port Community System

Multimodal booking platforms

Multimodal booking platforms are another innovative solution, optimizing cargo movement across different transport modes. These platforms provide features such as cargo or vehicle booking, process management, and tracking, enabling shippers to choose the best transport options based on cost, transit time, and environmental footprint. The systems integrate various processes, providing real-time data and analytics to enhance decision-making and operational efficiency. Such systems enable ports to handle increasing volumes of cargo and traffic more effectively, reducing delays and optimizing resource use.[20]

Predictive analytics and maintenance

Predictive analytics harness large datasets to forecast operational needs and potential issues, allowing for proactive management. By using historical and real-time data, ports can anticipate equipment failures and schedule maintenance before problems occur. This approach minimizes downtime and extends the lifespan of assets. Ports like Antwerp are leveraging predictive models to streamline vessel traffic and enhance operational efficiency, showcasing the transformative potential of this technology.[21]

Planning tools

Advanced planning tools are crucial for improving the efficiency of port operations. Digital document management systems and electronic invoicing platforms reduce administrative burdens and processing times. Furthermore, predictive maintenance systems use IoT sensors and data analytics to anticipate equipment failures, minimize downtime, and extend the lifespan of critical assets. Since 2014, a collaborative effort among the ports of Basel, Mulhouse, Weil am Rhein, Colmar-Neuf-Brisach, Strasbourg, Kehl, Karlsruhe, Mannheim, and Ludwigshafen, has been underway to develop the Rhine Ports Planning and Information System (RPIS). This cutting-edge platform represents a significant leap forward in traffic management for barge handling, enhancing operational efficiency across the board.[22]

Monitoring of emissions and other data

Environmental sustainability is a major driver of port digitalisation. Ports are integrating various digital tools to monitor and reduce their ecological footprint. Sensors for emission and noise detection, digital platforms for smart energy systems, and tools for waste reduction are becoming standard practices. Emission monitoring systems, such as the Maritime Emissions Portal at the Port of London, track pollutants and help ports adhere to environmental regulations. These technologies help ports comply with environmental laws and give broader climate resilience efforts.[23]

Traffic management and coordination

Traffic management within ports has seen improvements through the adoption of digital solutions. Real-time data analytics and AI-driven systems enhance the coordination and optimization of cargo movements. Advanced systems like the Traffic XHub at the Port of Trois-Rivières employ real-time data analytics and AI to optimize traffic flow, reduce congestion, and improve safety. These technologies provide stakeholders visibility into the movement of goods, enabling better decision-making and reducing delays.

Safety and security

Safety is another critical area benefiting from digitalisation. Technologies such as AI-driven surveillance, drones, and automated inspection systems are used to monitor infrastructure and detect

[20] GRIP D3.3 2.4 Summary of digitalisation potentials for four different port systems
[21] GRIP D3.5 2.10 Port of Antwerp – Antwerp Port Information & Control Assistant (APICA)
[22] GRIP D3.5 2.6 Rhine Ports – Rhine Ports Planning and Information System
[23] GRIP D3.5 3.10 Port of London – Maritime Emissions Portal

potential hazards. Blockchain technology is also being explored to enhance the security and transparency of supply chain transactions. These advancements help ports maintain high safety standards while improving the reliability and integrity of their operations.[24]

2.3.3 Gaps and barriers to digitalisation

Lack of standardization and interoperability

A major barrier to port digitalisation is the lack of standardization and interoperability among various digital systems. Ports and stakeholders often use diverse systems, creating difficulties in seamless integration. This inconsistency leads to inefficiencies and increased costs. For example, the Posidonia Operations system at the Port of Sevilla highlights the necessity for interoperable systems to streamline vessel traffic management effectively.

Cyber security threats

With increasing reliance on digital systems, ports are more vulnerable to cyberattacks. These threats, including data breaches, hacking, and ransomware, pose significant risks to port operations. Robust cyber security measures, such as firewalls and encryption protocols, are essential to protect sensitive data. The implementation of comprehensive cyber security measures at the Port of London underscores the importance of safeguarding digital infrastructure to ensure operational continuity.

Limited financial resources and skilled personnel

Successful digitalisation requires substantial financial investment and a skilled workforce. Many ports face budget constraints and a shortage of trained personnel, which can delay or limit the adoption of new technologies. The case study of the Port of Antwerp illustrates the impact of financial limitations on the pace of adopting predictive analytics tools, highlighting the need for strategic resource allocation and training programs.

Regulatory compliance

Navigating complex regulatory landscapes related to data privacy, environmental protection, and customs procedures is a significant challenge. Compliance with these regulations is essential but can slow down the implementation of digital tools. The Maritime Emissions Portal in the Port of London demonstrates how digital tools can aid in monitoring and reporting emissions, ensuring adherence to environmental regulations. More information about legislation can be found in the previous section.

Resistance to change

Digitalisation often requires a cultural shift within port authorities and among stakeholders. Resistance to change and a lack of awareness about the benefits of digitalisation can hinder its adoption. Effective change management strategies are crucial, including communication, training, and stakeholder engagement. Training programs at the Port of Rotterdam exemplify how stakeholder engagement can foster a supportive environment for digital transformation.

Technological evaluation and integration

Selecting the right technologies that are scalable, compatible with existing systems, and secure is a complex task. Ensuring interoperability and seamless integration with legacy systems is another significant barrier. The deployment of the Ci5 Port Community System in the Ports of Rhône highlights the need for careful technology selection and integration planning to avoid obsolescence and ensure long-term benefits.

Continuous improvement and iterative processes

Digitalisation is an ongoing process that requires continuous monitoring, feedback collection, and iterative improvement. Ports must commit to long-term investments and be prepared to adapt

[24] GRIP D3.3 (and D3.5 some examples) multiple sections

strategies based on evolving needs and technological advancements. The iterative enhancement of the Traffic XHub at the Port of Trois-Rivières illustrates the importance of maintaining a flexible approach to digitalisation, ensuring sustained progress and adaptability.

2.3.4 Conclusion

The digitalisation of ports transforms traditional operations and drives efficiency, sustainability, and competitiveness. However, major challenges remain in regulatory compliance, resource allocation, risk management, and sustainability integration. By addressing these barriers, ports can fully leverage digital technologies to enhance operations and contribute to global sustainability goals. The insights from ongoing projects and good practices provide valuable guidance for ports embarking on or expanding their digitalisation journey.

3 Analytical research method

3.1 Survey

A cornerstone of the project is the outreach to stakeholders by surveys as a way of increasing stakeholder engagement with the project and its results. The second survey offered room for this sub task to include a few questions. A couple of questions, derived from the interview questions (see below) have been submitted and a few have been selected by the survey organisers in Task 5.

Three questions were selected for the survey:

- *Considering the digital tools and applications currently in use at the port, do you believe they are being utilized to their full potential?*
- *Is there a need or are there expected benefits for the implementation of additional tools & applications in the port?*
- *In your view, what are the reasons these have not been implemented yet and what are the so-called barriers?*

These questions were selected as key questions from this sub task and having the most impact on the objectives and answering the questions of gaps and barriers posed there.

The survey was filled in by 32 respondents, mainly from inland ports and their stakeholders. The geographical spread was EU wide, while most respondents were found in Germany.

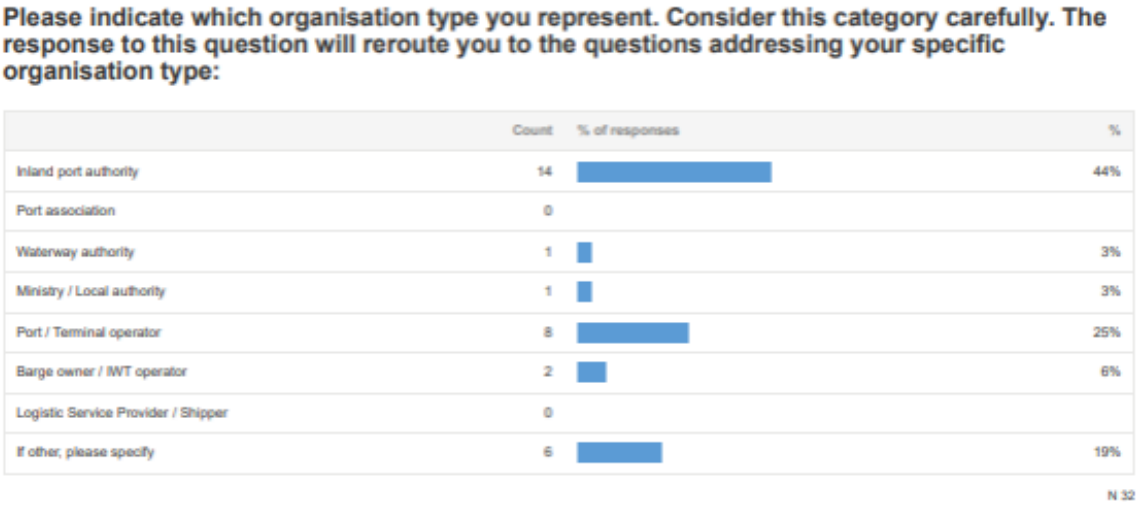

Figure 1: Types of respondents to the survey

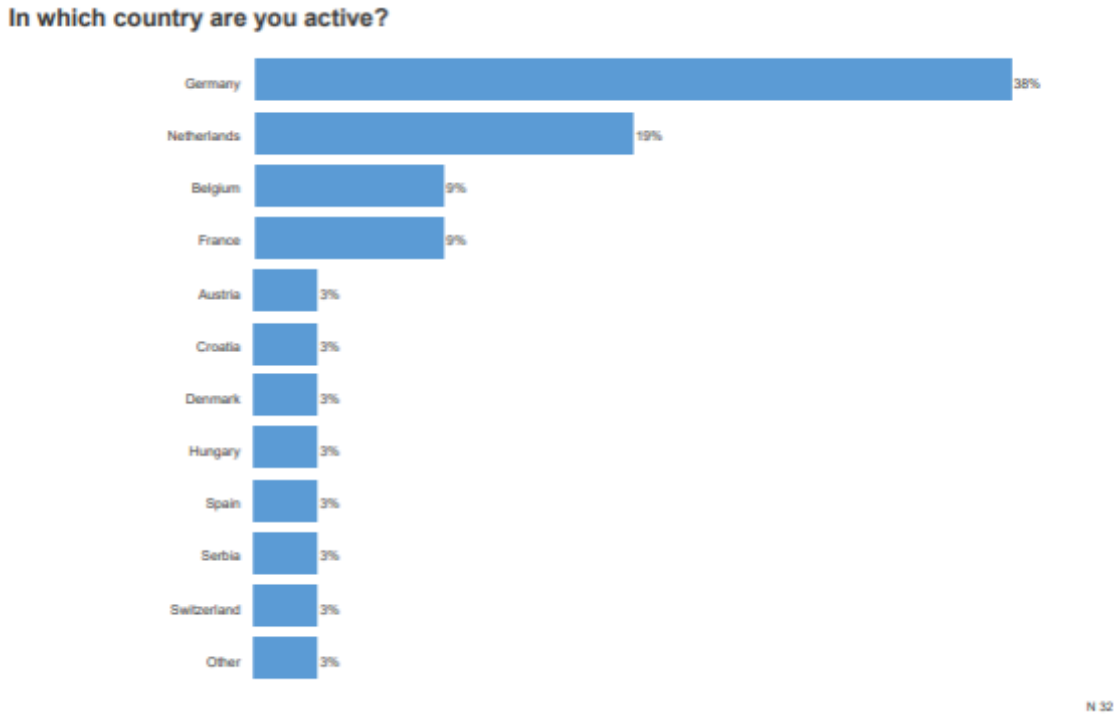

Figure 2: Geographical spread of survey respondents

Since the interviews have a strict geographical scope (see below) it was of key importance that the survey widened this scope. Given the figure above it clearly did so, therefore conclusions drawn from this sub task can be said to represent a broad geographical scope within Europe. The spread of respondent type is also positive: many port authorities and terminal operators broadened with some key stakeholders such as barge operators. The category “other” was asked to explain itself, which the respondents did. In general, respondents were from municipalities and in one instance a private actor operating ports that did not see themselves as port authorities because of multiple reasons.

3.1.1 Answeres to the survey questions

Considering the digital tools and applications currently in use at the port, do you believe they are being utilized to their full potential?

Twenty five respondents answered this question. A large majority (64%) of them felt additional benefits could be gained with increased or broader usage of digital tools and applications currently in use at the port. A significant minority (24%) felt currently used tools and applications were used sufficiently and 16% of respondents answered in specific other ways. The latter are mainly stating they do not know, the question is not relevant to them or pointing to operational examples in their port.

The response to this question shows that for a large number of respondents, improvements in (usage of) digital tools and applications could still be achieved.

Considering the digital tools and applications currently in use at the port, do you believe they are being utilised to their full potential?

	Count	% of responses	%
Additional benefits could be gained with increased or broader usage	16		64%
They are used sufficiently	6		24%
Other comments	4		16%

N 25

Figure 3 Currently used tools and applications. Response rate.

Considering the digital tools and applications currently in use at the port, do you believe they are being utilised to their full potential? - Other comments

Other comments	Report
n.a	
The port companies are currently working with their own applications. The port is planning a shore fee collection system for all shippers. This will simplify billing and the generation of statistical data, as there will be no need for double recording by the companies and the port	
Operator-level deployment	
idk	

N 4

Figure 4 Currently used tools and applications. Specification of choice of "other".

Is there a need or are there expected benefits for the implementation of additional tools & applications in the port?

Twenty three respondents answered this question. A majority (65%) of respondents answered positively on this question, while 35% answered no. This tells us that there are still advantages to be expected regarding implementation of additional tools and applications in inland ports. Respondents that answered yes, were directly asked what kind of tool or application they had in mind.

Respondents had a few clear categories in mind: basic needs of port authorities such as port fees and the related tracking of berth usage, planning & scheduling tools, energy management (in collaboration with supply chain stakeholders), overall data sharing, digital communication with customers and stakeholders, emission data platform and cyber assurance. These answers are clear signs for gaps in current coverage of available/used tools and applications.

Is there a need or are there expected benefits for the implementation of additional tools & applications in the port?

N 23

Figure 5: Additional tools and applications.

Which tools or applications would benefit the port?

Which tools or applications would benefit the port?	Report
port fees ship tracking berth reservation footprint calculations	
all, we would like to know more about all tools available.	
Data sharing tools.	
Energy Management Software Collaboration platform with all supply chain stakeholders	
Datasharing platforms and data spaces	
digital communication with customers, dispo and planning tool	
see Sealmless project	
Operator-level deployment	
RPIS	
Overall planning, scheduling and monitoring tool for assets in ports. Overall cyber assurance tool Overall Process management flow control system etc. etc.	
to be checked with private port opeartor	
Green Port Platform - emission data integration platform for ports	
the tools provided could be used more.	

N 13

Figure 6: Additional tools and applications. Specification.

In your view, what are the reasons these have not been implemented yet and what are the so-called barriers?

This question is of key importance to the research of this sub task since survey respondents are directly asked after the barriers for further digitalisation of inland ports. It can be observed that most barriers are of a financial nature, while legal, political and developmental barriers have also been mentioned. Looking into the specification question, it further seems HR or workforce related barriers are also important. Respondents note a lack of capacity regarding the workforce and a lack of knowledge there. There is also little awareness about the tools. Further mentioned are that for further digitalisation, cooperation between many entities would be necessary. Legal and especially financial barriers are strongly mentioned again and one respondent directly notes the government as a barrier.

In your view, what are the reasons these have not been implemented yet and what are the so-called barriers? And in your view, how can these barriers be mitigated?Barriers could be: legal, financial, technical/functional or HR/workforce-related.

Figure 7 Reasons for non-implementation

In your view, what are the reasons these have not been implemented yet and what are the so-called barriers? And in your view, how can these barriers be mitigated? Barriers could be: legal, financial, technical/functional or HR/workforce-related.	Report
workforce related, no capacity available financial lack of knowledge political interest for the port	
little awareness about the tools, HR...	
Legal, Financial, Technical, Operational, Political.	
Obstacles of a financial and personnel nature. Cooperation of many, different companies would be necessary	
willing to cooperate, trust is very important, data quality, transparency	
financial and it-capacity	
Supply chains are not offered from a single source; all stakeholders have different systems	
Further development needed to integrate and consolidate more processes on one plattform	
Our world is developing rapidly and implementation is along that route. Majority of development possibillities are only recently made possible.	
jurdisch en overheid	
mostly legal and technical/functional, less finacial or HR-related	

Figure 8 Reasons for non-implementation. Detailed answers.

Apart from the questions from this sub-task, the survey was filled with questions delivered by a number of other sub tasks. Of these, one was very interesting for the work in this sub task and has been listed below.

What are the major obstacles or challenges you face when trying to achieve interoperability between your inland port's digital tools and those of connected inland ports, seaports, and external stakeholders?

While it is good to note that this question focusses solely on barriers to achieving interoperability, the latter is a key part of further digitalisation steps. This makes the question very relevant for this sub task. Below can be seen what that only 31% of respondents here face no significant challenges, while a majority of 58% met with resistance from stakeholders. Smaller shares of respondents met with lack of standardised data formats, technological incompatibility, cyber security concerns, regulatory/governmental aspects and the development of several tools at the same time.

What are the major obstacles or challenges you face when trying to achieve interoperability between your inland port's digital tools and those of connected inland ports, seaports, and external stakeholders?

	Count	% of responses	%
Resistance from stakeholders	15		58%
Lack of standardised data formats	10		38%
No significant challenges	8		31%
Technological incompatibility	7		27%
Cybersecurity concerns	5		19%
Other (please specify)	3		12%

N 26

Figure 9: Interoperability obstacles and challenges

What are the major obstacles or challenges you face when trying to achieve interoperability between your inland port's digital tools and those of connected inland ports, seaports, and external stakeholders? - Other (please specify)

Other (please specify)	Report
regulatory	
Several tools under development at the same time	
overheden	

N 3

Figure 10: Interoperability obstacles and challenges. Specification of other answers.

3.1.2 Gaps and barriers flowing from the survey

As can be read above, the answers to the survey questions proved very interesting and did provide a number of gaps and barriers for further digitalisation.

- Although tools and applications might be available for them, not all basic port authority needs (Collecting port dues, Managing waiting- and long stay places for vessels to moor, Asset management, Safety, Enforcement of rules and regulations) are covered for a lot of respondents. Thus, there is still a gap to fill here.
- Several gaps were identified in less basic needs: energy management, digital communication, planning and scheduling, overall data sharing, emission data platforms. These areas are not (yet) sufficiently covered by digital tools and applications.
- Financial aspects have been most popular as answer to the question why these gaps haven't been filled yet. Apparently, budget is lacking to do so.
- Legal and political barriers to the same targets were also mentioned. Rules and regulations are seen as barriers and (local) politics and policy makers lack attention for inland ports and the digitalisation aspect.
- Workforce/HR related barriers were also often mentioned. One respondent clearly stated a lack of capacity and expertise to tackle the work coming with further digitalisation.
- The need for cooperation was sometimes offered as a barrier. This seems to make the challenge more complicated, although other respondents also mentioned a willingness to cooperate among stakeholders.
- Resistance from stakeholder however was mentioned as well regarding interoperability efforts.
- There could also be identified a lack of standardisation. For instance in data formats, but more general in the "how to" of digitalisation and interoperability efforts.
- Cyber security concerns, although not a prominent concern, were mentioned in the responses as well.

3.2 Interviews

Interviews were conducted in order to gather as much detailed information as possible, to validate the results from desk research and literature study and to delve into qualitative sources. The partners active in the sub-task reached out to a wide range of inland ports and stakeholders for interviews, but the response rates were disappointing. Therefore, mitigation measures were taken by changing the target of the outreach from individual ports to organizations representing inland ports. Although only five interviews were executed, by targeting representatives, the sub task partners indirectly spoke to stakeholders/experts from almost every inland port in the Netherlands.

First, an interview was conducted with the Dutch Inland Port Association (Nederlandse Vereniging van Binnenhavens), an association representing their members. Either directly through individual membership, or because of membership of the governmental layer above the individual inland port, almost every inland port is a member of this association. This interview was followed up by interviews with three communal port authorities: a port authority body acting as port authority (or taking up parts of that workload) for multiple inland ports[25]. Combined, these communal port authority bodies take up (part of the) port authority responsibilities and tasks for 34 small- and medium sized Dutch inland ports. To get a stakeholder perspective, a service provider for a port scheduling system was interviewed as well, they were able to give insight into the stand of digitalisation for Dutch frontrunners.

This mix of interviewees provides a dense geographic coverage were attention could be paid to the smaller ports in the hinterland. These ports often lack the sophistication regarding digital systems and have not yet been the target of large scale investigation regarding the subject. At least, not as much as larger inland ports, or the largest ports in the Netherlands: seaports combining inland and seagoing services such as Rotterdam and Amsterdam. In the latter, significant digitalisation efforts have already been made.

Interview reports are available for GRIP consortium members on the respective online communication channels. However, sub-task partners opt not to publish them in this report since interviewees often represent multiple ports over multiple municipalities with multiple decision making bodies. Therefore, a misinterpretation of answers to interview questions could potentially harm interviewees in their day to day work. Generalising interview outcomes however does not impact the results of the interview process and the lessons learned significantly. Therefore, the results have hereunder been given in an aggregated and anonymised manner.

3.2.1 The interview questions

The sub-task description clearly states "*The objective of this sub-task is to look at gaps and barriers affecting the development and implementation of digital tools and applications at port administration/authority level and at port community level across the several stakeholders involved.*" Therefore, interview questions have been drafted, assessed and reviewed to align interviews with this objective.

The questions agreed upon by the sub task partners are listed below for reference.

1. *Which digital tools & applications do you use, which are used in the port you operate in, and what purpose do they serve?*
2. *Considering the tools and applications currently in use at the port, do you believe they are being utilised to their full potential? If not, which tools and why not? What are the so-called*

[25] See below for an explanation of the term flowing from the interviews.

barriers here? How can these be mitigated? Barriers could be: legal, financial, technical/functional or HR/workforce-Related.

3. *Is there a need for, or are there expected benefits from, the implementation of additional tools & applications in the port? If so, which and what are the reasons these have not been implemented yet?*
4. *Again, looking at the known tools and applications that target port operations: do these already cover all fields of the port that could be served by digital tools and applications? E.g., which problems can still be answered by (existing or to-be-developed) digital tools & applications?*

3.2.2 Aggregated and anonymised answers to the interview questions

Question 1. Which digital tools & applications do you use, which are used in the port you operate in, and what purpose do they serve?

A broad range of digital tools is in use by inland ports, but although some reach up to the same level of sophistication as seen with port community systems including planning tools used in some seaports, most are targeted at basic needs for the port authority:

- Collecting port dues;
- Managing waiting- and longstay places for vessels to moor;
- Asset management;
- Safety;
- Enforcement of rules and regulations.

Although these aspects are basic needs for every port authority, there is no one size fits all solution on the market at the moment. Currently inland ports use a plethora of systems to cover their basic needs which are often not interchangeable or interoperable and lack user friendliness. Some ports even track the movement of vessels in the port and some have digital management of the onshore power supply, but it remains not similar to other ports and many also lack this. An often-heard complaint from vessel operators is the need to use another system for a neighbouring port only a short distance away.

Further, the level of digitalized covering of these basic needs is, outside of the largest inland ports, rather low. There are a number of ports where the process is not digitalised at all, and larger amounts of ports are not fully digitalised or use half-way measures such as self-billing by vessel operators of port dues (i.e. vessel operators send the port a statement at the end of the year with how many times and how long they made use of the port, the port then sends them a bill. No checks are made by the port). Only a couple of ports have totally digitalised systems for collecting (and paying) port dues.

Regarding asset management, a lot of ports lack digital systems for this. Therefore, there is often no clear overview of the state of the critical infrastructure in the port which leaves the port vulnerable to disruptions when infrastructure breaks down. There are even a lot of ports whose municipalities do not have a clear source of funding for infrastructural maintenance and repairs. Therefore, if something breaks down, they have to look for budget to repair/replace it on an ad-hoc basis.

Question 2. Considering the tools and applications currently in use at the port, do you believe they are being utilised to their full potential? If not, which tools and why not? What are the so-called barriers here? How can these be mitigated? Barriers could be: legal, financial, technical/functional or HR/workforce-Related.

The general consensus here is that tools and applications are not yet used to their full potential, especially outside of seaports. A key hurdle here is that smaller inland ports clearly see themselves in a partly digitalized situation, they further have no means to push their customers and stakeholders towards total digitalisation so they will always have to have non-digital (or less digital) options available. Therefore, benefits of further digitalisation are sometimes seen as low. A key example here are the port dues and their collection. It is technically possible to collect port dues by automatically following vessels by AIS and accounting for their time stayed in the port. However, AIS data is not available for ports to use in this way and vessel owners would need to give permission to do so. Since vessel owners cannot be forced to do that, a non-digital way of reporting port dues must continue to exist even if a sophisticated system was put in place.

Other barriers to further digitalisation are of a management perspective. This has a lot to do with how small ports are governed and operated. Almost always, small ports are the responsibility of the respective local municipal government. Municipalities however are mostly driven by the need to service their inhabitants and to do so within a strict budget. Many municipalities are having trouble keeping to their budget as it is and see higher governmental layers push more responsibilities towards them. This combination results in sub optimal attention for small local ports within municipalities. Often, there is not one division within the municipality that has the responsibility over all aspects of the port. This leads to sub optimal management, the lack of a vision for the port- let alone a digitalisation vision. Some municipalities do not know what the port revenues are, and although the common management profile is that of the landlord, (where port plots are rented out) some municipalities have sold port plots to private parties to enhance their cashflow in the present. For the future however, this means a loss of rent from this plot and a decrease in port revenue- there are municipalities that have sold every port plot in the port and thus have lost all rental income for the future. Concurrently, interest in spending money to maintain and operate the port (which is now not very profitable) will decrease as well.

The above can be fixed by cooperating with other municipalities regarding the port authority duties, which happens and helps, but for many municipalities local ports remain one of the last budget items to spend money on. Furthermore, permit policy allows municipalities a lot of ways to influence and manage their ports even if all port plots have been sold.

It was further put forward that not all software is sufficiently prepared for the future, currently in use systems (for instance for port due collection and registrations) is not always suitable for future development and innovative use cases. That would mean extra time, effort and money would be needed to change the systems in place if further innovations are to be rolled out.

Question 3. Is there a need for, or are there expected benefits from, the implementation of additional tools & applications in the port? If so, which and what are the reasons these have not been implemented yet?

There are areas where this is the case. Availability statuses of port facilities could still be made better available to vessel operators by integrating this information in ECDIS applications (the digital maps vessel operators use for navigation). This would also be of key importance regarding the transition to a zero emission inland shipping sector. EU targets already state that inland ports should make green energy available to the sector, as it is becoming likely that more energy supply locations will be needed if the step to green energy is to be made. However, that would also mean that vessel operators would need to be able to see if energy supply locations are available and what kind of green energy is offered / in stock. Digitalisation would be the answer for that.

Further, Port dues digitalisation, although not exiting at a first glance, will give clear insight in both port revenues as well as the volume of the flows of goods going through the port. It is key that these developments are done open source so they are not locked in with one or a few commercial providers of services.

Question 4. Again, looking at the known tools and applications that target port operations: do these already cover all fields of the port that could be served by digital tools and applications? E.g., which problems can still be answered by (existing or to-be-developed) digital tools & applications?

Here, answers are mixed. It seems that outside of those instances where basic port authority needs are not yet met, interviewees did not see that many opportunities. An interesting option could be to roll out port community systems from seaports also to inland ports in the hinterland. However, the benefit of these systems is that they provide the optimal way of managing port facilities and terminal handling slots given scarcity for these. In many inland ports, there are no waiting times for handling or port facility usage- so a (sea)port community system there would solve a problem that does not exist. Inland ports and the terminals that operate in them are mostly catering to local stakeholders regarding outgoing information flows, while incoming information is coming from seaport terminals.

Basic digitalisation of port authority needs must also include general knowledge about the port and what it means to the local and national economy in terms of socio economic benefits and welfare. With this information in hand, municipalities can better assess what their port represents and funds would be easier to find.

The Communal Port Authority Body

As can be seen in the interview answers, and as was explained earlier, the largest share of interviews has been held with parties that take up (a share of) the port authority workload for multiple ports, usually clustered in a specific geographical region. Since smaller inland ports are often found in small municipalities that lack the organisational or management strength to optimally manage the port, or sometimes in larger municipalities that are unwilling or unable to attribute the budget and manpower needed to do so, a significant number of municipalities in the Netherlands has decided to cooperate regarding port management and port authority tasks.

Cooperation usually entails the creation of an organisation that employs staff and has budget to carry out a range of port authority and port management tasks. See for a common example of such tasks the basic port management needs described under the first interview question above. The idea behind this cooperation is that by doing so, small local budgets and manpower can be merged to cover the basic needs of the ports governed by the associated municipalities. This strategy forms an effective work-around for the lack of organisational power and budget available for individual ports under the responsibility of small municipalities. It is however not a total solution since the communal port authority bodies can still be hampered by budget shortages and lack of staff from the associated municipalities as usually budgets need to be approved by each associated municipality.

The legal status of these bodies can vary from an informal cooperation of municipalities to a specific organisational body with full legal status. Usually, the body is governed by a board with members which are appointed by each of the associated municipalities.

3.2.3 Gaps and barriers flowing from the interviews

Hereunder follows an overview of the most commonly found gaps and barriers for digitalisation identified during the interviews.

- Lack of organisational power in municipalities;
    - Appearance: often not one port division, little attention for and knowledge of the port, no specialised staff for the port.
    - Result: no local strategies, port is often not optimally managed, no knowledge of benefits and possibilities of digitalisation.

- Lack of budget for ports in municipalities;
    - Appearance: little attention/knowledge leads to little budgets.
    - Result: often low maintenance, risk of no budget for repairs, no strategies for digitalisation.

- Lack of organizational power in companies;
    - Appearance: similar to municipalities, companies (vessel operators) often lack expertise and money to digitalize their side of the business.
    - Result: a (partly) digitally lagging user group, disrupts digitalisation benefits.

- No overarching strategy for transport sector, or IWT sector;
    - Appearance: no EU/national vision that pinpoints the needs for the transport sector and thus for ports.
    - Result: ports and transport depend on local strategies.

- No clarity on availability of subsidies for ports for digitalisation and other challenges;
    - Appearance: subsidies are available, but hard to find and not always easily matched with local needs.
    - Result: ports miss out on opportunities.

- Non-enforcement of digitalisation;
    - Appearance: even if digitalisation is rolled out, the non-digital option must often remain available.
    - Result: this means costs of the non-digital way cannot be scrapped, decreased benefits of digitalisation.

- A clear roadmap for digitalisation is lacking;
    - Appearance: no standardized plan to digitalize a port is available.
    - Result: every port “reinvents the wheel” and the field is left with many differen solutions. No standardization.

- Minimal requirements for digitalisation are not in place;
    - Appearance: both for ports and stakeholders almost no minimal requirements for digitalisation are set.
    - Result: This keeps in play the non-digital option.

- Old systems not always suitable for further innovations;
    - Appearance: systems in place often are not designed for the next step in digitalisation.
    - Result: extra costs to overhaul these basis-systems for further digitalisation.

3.3 Desk Research

A third source of information has been desk research to gaps and barriers. This research has been conducted in step with the literature analysis (see above). The literature analysis already contains an overview of the literature found and scanned for gaps and barriers, this will not be duplicated here. However, apart from found literature there were also a number of interesting projects, studies and documents identified that proved very relevant and/or took stock of gaps and barriers regarding digitalisation in inland ports themselves. Several (EU) projects are discussed in this section. A summary of the project and its main conclusions will be provided. The gaps and barriers of these projects will be considered.

The following relevant projects, studies and documents are analysed and will be discussed in this section: DIWA Masterplan project, DG MOVE Digitalisation Vision document, Strategische Agenda 2020-2025 document (Dutch Inland Port Federation, NVB), PLATINA3 project, MAGPIE project, PIONEERS projects and DINA study.

3.3.1 DIWA Masterplan project

The *DIWA (Digital Inland Waterway Area) Masterplan* project outlines a strategy for digitalizing Inland Waterway Transport (IWT) in Europe. It aligns with several European strategies, such as the EU Digital Single Market Strategy, the European Green Deal, and the European (Open) Data Strategy, aiming to modernize IWT, improve efficiency, safety, reliability, and sustainability, and boost its competitiveness within the multimodal transport network. The DIWA Masterplan project also emphasizes the importance of digital transformation in making waterways more attractive and sustainable and integrating IWT into the multimodal transport network.[26]

Gaps and barriers according to DIWA Masterplan deliverables:

Interoperability issues

One major gap is the interoperability between different digital systems and platforms. For example, integrating EuRIS (European River Information Services) with other transport modes is crucial, but currently challenging due to differences in data formats and standards. Projects like eFTI (electronic Freight Transport Information) aim to lower these burdens, but discrepancies between systems (e.g., eFTI and ERI - Electronic Reporting International) should be minimized.[27]

Data quality and calibration

The reliability of sensor data is another barrier. Ensuring high data quality and correct calibration of emission-related sensors is essential for making accurate decisions. Future challenges include affordability and the need for fall-back options and cyber security measures.[28]

Cyber security concerns

As digital tools become more prevalent, the importance of robust cyber security measures increases. There is a need for adequate data protection to build trust among stakeholders and ensure safe digital interactions. For successful cooperation in multimodal transport, sufficient cyber security and data protection measures are essential to maintain trust among stakeholders.[29]

Harmonization and standardization

[26] DIWA (Digital Inland Waterway Area) Masterplan https://www.masterplandiwa.eu/wp-content/uploads/2023/11/DIWA_Masterplan_final_October_2023.pdf

[27] DIWA 3-4 https://www.masterplandiwa.eu/wp-content/uploads/2023/03/Masterplan-DIWA-project-3.4-final-report-Oct2023.pdf

[28] DIWA 3-3 https://www.masterplandiwa.eu/wp-content/uploads/2023/03/Masterplan-DIWA-project-3.3-final-report-Oct2023.pdf

[29] DIWA 4-3 https://www.masterplandiwa.eu/wp-content/uploads/2023/06/Masterplan-DIWA-project-4.3-final-report-Oct2023.pdf

The lack of standardized data sets and interfaces hinders the efficient exchange of information across different transport modes. Harmonizing these aspects is necessary to achieve a seamless digital transformation.[30]

Technical and economic barriers

The implementation of new technologies often faces technical challenges and high initial costs. For instance, deploying smart sensors and IoT devices requires substantial investment and technical expertise, which can be a barrier for smaller operators. Inland waterway ports may not be prepared for or surprised by new technologies.[31]

Legal and regulatory

Currently, only partial areas (EU or national) have been regulated in the field of IWT. Legislators are challenged to enable the implementation of new technologies and create new legal structures for using those technologies. [32]

3.3.2 DG MOVE Digitalisation Vision

The DINA study from 2017 states that the IWT sector must keep up with digital developments (both horizontal developments and developments in other modes of transport) to improve the sector's competitiveness and ensure that it becomes an active part of a broader multimodal chain. Based on the results of the DINA study and the input of the members of the DINA Expert Group four main challenges have been identified in the *DG MOVE Digitalisation Vision* that pose a threat to the competitiveness of the IWT sector. [33]

Gaps and barriers according to the DG MOVE Digitalisation Vision document:

Inefficient navigation and traffic management

Limited availability of real-time information and not harmonized standards of data on traffic conditions is a problem for barge operators. It makes it difficult for them to adapt their voyage plans based on real-time conditions. This leads to unnecessary delays, reduced quality of service (in terms of punctuality/reliability), and unnecessarily high fuel burn (e.g., to compensate for delays). These problems affect all barge operators. The underlying is the reluctance to share detailed voyage plans with the fairway authorities This makes it difficult to execute smart navigation schemes in waterway corridors.

Integration of IWT in logistics processes under development

One of the problems is generally the fact that current supply chains are not always adequately designed for efficient integration of IWT. This requires a certain understanding from cargo owners about the process of IWT and a possible need and willingness to redesign their present (intercontinental) supply chains. The biggest challenge is to connect all the different systems in use and make the elements available in a standardized format, allowing parties to send and receive the data and information they own or require for their specific part of the process.

Administrative burden and costs involved in complying with and enforcing legislation:

Barge operators need to comply with relevant legislation – both safety-related and non-safety-related. Barge operators indicate that they must file the same data multiple times. This is because they must comply with different aspects of legislation caused by different jurisdictions in cross-border operations. Compliance with legislation therefore represents a high administrative burden for barge operators, as well as high costs for the authorities that must verify their compliance. The underlying problems are the existing 'declaration-based' reporting system and the limited re-use of data by authorities.

[30] DIWA 4-1 https://www.masterplandiwa.eu/wp-content/uploads/2023/06/Masterplan-DIWA-project-4.1-final-report-Oct2023.pdf
[31] DIWA 3-1 https://www.masterplandiwa.eu/wp-content/uploads/2023/03/Masterplan-DIWA-project-3.1-final-report-Oct2023.pdf
[32] DIWA 4-2 https://www.masterplandiwa.eu/wp-content/uploads/2023/06/Masterplan-DIWA-project-4.2-final-report-Oct2023.pdf
[33] DG MOVE IWT Digitalisation Vision 2023

Shortage of qualified personnel

A shortage of qualified personnel poses challenges in speeding up a digital transition in the IWT industry. Automation can help to make the sector more attractive, by giving remote control vessel operators the possibility to work from their place of living in a normal office environment, by the digital upskilling of the workforce, and by creating attractive jobs for old and young in the logistics sector.

3.3.3 Strategische Agenda 2020-2025 (Nederlandse Vereniging van Binnenhavens)

According to the *Strategic Agenda 2020-2025* document of the Dutch Association of Inland Ports (*Strategische Agenda 2020-2025* – Nederlandse Vereniging van Binnenhavens) the bottlenecks that inland ports experience in the future development of digitalisation are a lack of central policy and management. There is currently insufficient knowledge of the possibilities of digitalisation in inland ports. It is needed from the inland ports' knowledge transfer and information provision regarding the smart use of data and data systems and the implementation of these systems. [34]

3.3.4 PLATINA3 project

The project report *PLATINA3 D4.3 - Digital and Automated Infrastructure* outlines the current state of digitalisation in inland ports across Europe, emphasizing disparities in digitalisation. While some ports are highly advanced, others (particularly in the Danube Region) remain at basic or initial levels of digital integration. The benefits of digitalisation include enhanced operational efficiency, improved safety, and better sustainability outcomes. However, the report underscores the necessity for a structured roadmap to address the varying levels of digital maturity and to facilitate widespread adoption of digital tools.[35]

Gaps and barriers according to PLATINA3 D4.3:

Regional disparities:

Inland ports in the northern regions of Europe tend to be more digitally advanced compared to those in the southern regions and the Danube area.[36] Many tasks in Danube Region ports are still performed using outdated methods like emails, spreadsheets, and phone calls. Communication platforms among port stakeholders are often missing, leading to a low digital maturity level (0 or 1) compared to other regions. This creates a digital divide that hinders uniform progress across the sector.[37]

Collaboration challenges:

There is a lack of effective digital collaboration between private and public entities. This hampers the full potential of digital technologies in enhancing supply chain efficiency. Better digital collaboration is needed across the supply chain to improve operational efficiency and service levels. This includes coordination between port authorities, logistics service providers, and terminal operators. [38]

Infrastructure deficiencies:

Many inland ports lack the necessary digital and physical infrastructure, such as comprehensive communication platforms and integrated monitoring systems, which are crucial for digital operations.[39]

Data management issues:

[34] https://havens.binnenvaart.nl/publicaties/599-strategische-agenda#digitalisering
[35] PLATINA3 D4-3 https://platina3.eu/download/digital-and-automated-infrastructure/
[36] Project DIONYSUS. Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chains. URL: www.interregdanube.eu/dionysus.
[37] PLATINA3 D4-3 p. 55
[38] PLATINA3 D4-3 p. 67
[39] PLATINA3 D4-3 p. 67

Problems related to data sharing, ownership, protection, and security pose barriers. Many ports lack instant digitalized monitoring systems beyond basic CCTV. Cyber security is also a concern, with many ports not considering their current digital solutions as reliable. Effective digitalisation requires robust data management frameworks, especially in multinational contexts.[40]

Policy and support shortcomings:
There is insufficient policy support and funding for developing and managing digital infrastructure in ports. This affects the implementation of digital technologies and hampers modernization efforts. Ports require more support from EU and national transport policies to foster development and management. This includes establishing a proper legal framework with mandatory requirements and incentives for digital infrastructure improvements[41]

3.3.5 MAGPIE project

Two deliverables of MAGPIE investigate the gaps and barriers. In MAGPIE D4-1 Digital platforms and services some gaps were identified:[42]

Gaps according to MAGPIE project:
Lack of real-time data on energy consumption
Many port authorities do not have real-time information on energy consumption due to their landlord business model and lack of ownership of the electricity grid. Data are often recorded on paper or worksheets, which prevents efficient monitoring and optimization of energy use.

Underutilization of available data
Even though some port authorities collect data on particulate matter emissions, this information is not being fully exploited to optimize operations, reduce emissions, or enhance energy efficiency at the port level.

Inconsistent data formats across port ecosystem
Different actors within the port ecosystem, such as terminals and road transport operators, often use non-standard data representations. This inconsistency hinders data reuse and integration across various platforms.

Absence of a knowledge representation model
The lack of a standardized knowledge representation model makes it difficult to integrate the multiple platforms used by different actors within the port ecosystem. This limits the ability to foster sustainable and efficient operations.

Limited real-time visibility for multimodal Operations
Without real-time information sharing among all actors in the supply chain, it is challenging to promote sustainable multimodal operations, where multiple modes of transport are synchronized.

Manual data input in port community systems
Although some ports use Port Community Systems and Logistics Single Window platforms to centralize data, much of the data is still provided through human input. This manual process limits the platforms' efficiency and the potential for automating greener operations.

Limited functionality for evaluating KPIs and decision support

[40] PLATINA3 D4-3 p. 55
[41] PLATINA3 D4-3 p. 67
[42] Magpie D4-1 Digital platforms and services https://www.magpie-ports.eu/wp-content/uploads/2023/01/Deliverable-D4.1-Digital-platforms-and-services.pdf p. 42

Existing platforms have limited capabilities for evaluating Key Performance Indicators (KPIs), supporting decision-making, and simulating or optimizing operations. This restricts the potential to improve efficiency and reduce environmental impact within ports.

In *MAGPIE D7-1 Barrier Analysis* several barriers were identified:[43]

- **Economical**: Lack of business case for solution suppliers due to small numbers of inland vessels in the market in comparison to the automotive or maritime shipping market (both in total number of vessels and the number of vessels per market segment) (economic).
- **Knowledge**: Lack of capacity to build expertise for stakeholders in comparison to the complexity of the (technical, operational, regulatory) changes. Also a lack of system-level insight (e.g., data, decision models) for policymakers.
- **Regulation:** Standard complexity too high for inland (e.g., due to leaning in seagoing)
- **Niche**: Inland shipping is seen as niche (e.g., embedded in other policies).
- **Infrastructure**: Uncertainty linked to the infrastructure required to support new technology.

3.3.6 PIONEERS project

The *PIONEERS project deliverable D3.1 Current State-Of-The-Art, Enablers, Barriers and Challenges* addresses the current state of ports in terms of sustainability, digitalisation, and their ongoing efforts to reduce environmental impact. The main findings are structured around the four pillars of the PIONEERS project: sustainability, greening, digitalisation, and operational efficiency.[44]

Gaps and barriers:

Data integration

Each stakeholder has its own (technical) data structure and hardware. These need to be used and integrated into the vessel traffic optimization. The lack of widely adopted standards for IoT devices makes difficult the reusability of solution at other ports without significant changes in the data acquisition layer.

Data sharing barriers

The different actors in the logistics chain sometimes perceive sharing their data as a risk instead of an opportunity. Sharing of data as many stakeholders are careful in sharing data since they are considered a strategic advantage not for public use. Having historical data (both from traffic and cargo) will allow us to develop far better machine-learning models to develop a Cargo Flow Predictor allowing us to make smart strategic decisions. Additionally, if shippers and other actors (for example rail operators) share their data it will allow the development of capacity and availability tools for multimodal transport. Potential users must understand the benefits of sharing the data from a business perspective.

Computational power

The solution space becomes exponentially bigger when more stakeholders and their objectives are involved. The solution space is also getting bigger because of the strongly increased number of vessels visiting ports. This together puts strong demands on the computational power of the IT systems used in optimization.

Other gaps and barriers

More challenges were identified, but not further explained in this deliverable including:

- Privacy and security

[43] Magpie D7-1 Barrier Analysis https://www.magpie-ports.eu/wp-content/uploads/2023/01/Deliverable-D7.1-Barrier-Analysis.pdf pp. 16-17

[44] Pioneers Project D3.1 Current State-Of-The-Art, Enablers, Barriers, and Challenge https://pioneers-ports.eu/wp-content/uploads/2024/07/State-of-the-Art-Gaps-and-Challenges-for-Green-Ports.pdf pp. 83-89

- System governance and ownership
- Expertise and knowledge of staff
- Redesign existing policies
- Willingness among relevant stakeholders
- Dissemination of information
- New business models
- Mind shift required for cooperation
- The fragmentation of the market of logistics service providers makes it difficult to introduce standards for data sharing

3.3.7 DINA study

Digital Inland Waterway Area (DINA) results from a study on the future digitalisation of inland waterway transport. Three main challenges that were investigated in project DINA were: (1) inefficient navigation and traffic management, (2) inefficient integration of IWT in logistics processes, and (3) high administrative burden for complying with legislation. The report prepared by a consortium led by TNO was written in 2017; some information might be outdated today.[45]

Gaps and barriers according to DINA study:

Lack of up-to-date traffic information for barge operators

Barge operators often lack access to real-time traffic information, which is crucial for efficient voyage planning. Without up-to-date traffic conditions, operators cannot provide accurate estimated times of arrival (ETAs) to their customers, leading to operational inefficiencies and reduced customer satisfaction.[46]

Inadequate sharing of voyage plans with fairway authorities

Skippers typically do not share their detailed voyage plans with fairway authorities. This lack of information sharing makes it difficult for authorities to manage traffic effectively, potentially causing congestion and delays in navigational corridors. Improved coordination and communication between skippers and authorities are needed to optimize traffic management.[47]

Limited integration with shippers' and logistics service providers' systems

There is a gap in the integration of barge operators' systems with the booking and cargo management systems used by shippers and logistics service providers. This disconnect limits the adoption of advanced logistics planning concepts and reduces the overall efficiency of transport operations. Seamless integration is essential for enhancing the competitiveness of inland waterway transport.[48]

High administrative burden from 'declaration-based' reporting

Skippers are required to submit multiple reports and mandatory declarations to authorities, creating an administrative burden. The limited reuse of reported data exacerbates this issue, as the same information often must be submitted multiple times for different legislative requirements. Streamlining reporting processes and improving data reuse could alleviate this burden.[49]

Legal and commercial bottlenecks in data sharing

Legal and commercial restrictions often prevent the sharing of certain data among stakeholders. Privacy legislation, for example, restricts data sharing stored in the European Hull Database (EHDB)

[45] https://transport.ec.europa.eu/system/files/2017-12/2017-10-dina.pdf
[46] DINA p. 45
[47] DINA p. 47
[48] DINA p. 47
[49] DINA p. 48

with third parties, limiting it to specific fairway authorities and other designated actors. Addressing these legal and commercial bottlenecks is necessary for improving data flow and cooperation.[50]

Fragmented and inconsistent digital systems

The digital systems used by different stakeholders in the inland waterway sector lack standardization and interoperability, leading to fragmented and inconsistent operations. This fragmentation creates barriers to seamless data exchange and coordination across the sector. Standardizing systems and ensuring interoperability are critical steps toward enhancing digitalisation.[51]

The IWT sector is limited in size and fragmented

The IWT sector is limited in size and fragmented across industries and regions. This makes it difficult to achieve economies of scale and provide an attractive market for commercial actors to develop solutions. A limited number of equipment manufacturers often provide services to various areas of waterborne transport and a limited set of specific software solutions is used for inland waterway transport.[52] An example is the BICS application which is commonly used for submitting electronic ship reports.[53]

High fuel consumption for barge operators (consequence)

Inefficiencies in voyage planning and traffic management contribute to higher fuel consumption for barge operators. Increased fuel consumption raises operational costs and has negative environmental impacts, reducing the sustainability of inland waterway transport. Optimized planning and management can lead to more fuel-efficient operations.[54]

3.3.8 Gaps and barriers flowing from the Desk Research

Hereunder follows an overview of the most commonly found gaps and barriers for digitalisation identified during the desk research of the problems analysed above.

- Interoperability issues
  - Appearance: integration of systems with other ports, modes of transport etc. is difficult.
  - Result: hinders digitalisation and uptake of IWT and inland ports in wider supply chain systems.
- Data reliability
  - Appearance: data is not always reliable enough to build decisions and plans upon.
  - Result: hindrance for uptake of decision-making and monitoring systems.
- Computational power demands
  - Appearance: the larger the user-base and dataflows handled by digital systems, the large the computational power needed for them to operate.
  - Results: strong demands on system capacities.
- Data sharing issues
  - Appearance: data sharing is often seen as a risk.
  - Result: less data shared than optimal, digital systems sometimes miss data for efficient operation.
- Cyber security issues
  - Appearance: measures needed to maintain trust from stakeholders.
  - Result: at least added costs for these measures, at worst lost stakeholder trust in case of failure.

[50] DINA pp. 50-51
[51] DINA pp. 51-53 and more across chapter 3
[52] DINA pp. 55-56
[53] https://www.bics.nl/nl
[54] DINA p 46

- Standardisation and harmonisation
    - Appearance: datasets and interfaces are not sufficiently standardised.
    - Result: hinders efficient information exchange across different ports, stakeholders and modes of transport.
- Limited availability of real-time data and information
    - Appearance: eta's, emissions data, availabilities in ports etc. often not available real-time.
    - Result: IWT operators operate vessels less efficient than possible.
- Legal framework
    - Appearance: rules and regulations not covering all aspects yet.
    - Result: inadequate rules also represent a lack of guidelines for development of systems.
- Financial
    - Appearance: implementing new technologies of systems requires high initial costs.
    - Result: some ports not taking up new technologies.
- Shortage of staff
    - Appearance: logistic-sector wide shortage of qualified staff.
    - Result: often lacking capacity to implement new systems.
- Regional disparities
    - Appearance: large geographical differences regarding level of digitalisation.
    - Result: hindrance of uniform EU-wide progress. Difficulties for region-transversing operators.
- Collaboration issues
    - Appearance: lack of effective digital collaboration between private and public entities.
    - Result: reduces the potential of digital technologies in enhancing supply chain efficiency.
- Insufficient policy guidance
    - Appearance: few strategies, guidelines and subsidies from high-level governments on (port) digitalisation available.
    - Result: This affects the implementation of digital technologies and hampers modernization efforts.
- Limited functionalities for decision-making
    - Appearance: current systems have limited options to evaluatu KPI's.
    - Result: knowledge left un-used for decision-making.
- Infrastructure
    - Appearance: ports and stakeholders cannot yet be sure what infrastructure is required to support digital innovations in the further future.
    - Result: no guided steps to prepare for the future here can be taken.

4 Gaps and barriers

The goal of the sub-task 3.4 of GRIP study is to look at gaps and barriers affecting the development and implementation of digital tools in inland ports. By means of interviews, a survey and extensive desk research a list of gaps and barriers has been identified. During this identification process it could be observed that a vast majority of the identified gaps and barriers could be classified according to four categories: legal-, financial-, technical/functional- and HR/Workforce- gaps and barriers. In this chapter 4, the gaps and barriers are aggregated and presented according to these four categories.

4.1 Legal gaps and barriers

Results for legal gaps and barriers mostly flow from desk research. In the interviews and the survey the discussion regarding the legal framework was more general with responses and interviewees stating that they saw the legal framework as dense and sometimes not easy to navigate or oversee. They also explicitly mentioned a lack of standardisation, leaving inland ports with many options for digitalisation and unsure of which would match the best with stakeholder systems, wants and needs. The non-strictness of regulations regarding digitalisation was also mentioned as a significant barrier for further digitalisation. By explicitly allowing a non-digital way of execution for a large part of the operations in the supply chain, regulators support the continuous existence of an in-between situation. In this in-between situation, digitalised and non-digitalised parties exists next to each other and port authorities have to service them both. For the latter, this means that the non-digital way of operations must remain available, which renders the benefits of totally scrapping these services (mostly cost reductions regarding personnel costs) void- and thus makes digitalisation less attractive. After all, part of its benefits are reduced.

The desk study, heavily supported by earlier work in this task, also clearly underlines this and adds several interesting points. One of the most significant is the regulatory fragmentation. Since there is no specific European (or international) legislation for the digitalisation of ports. The relevant legal framework is spread across multiple directives and regulations, some still in the proposal stage. Especially for smaller ports, this fragmentation can make compliance challenging (and/or costly). Further, broad or vague definitions in the regulatory framework sometimes create uncertainty. Furthermore, data sharing and the legislation surrounding it is proving a serious issue. Ports must then keep a strict balance between protection of data rights and the benefits flowing from data sharing. Data sharing is hampered by legal restrictions (GDPR for personal data, the Open Data Directive and the Data Governance Act that distinguish between open and sensitive data and stakeholder unwillingness to share data in general). Since digital tools often require data sharing, they are heavily impacted if data is not optimally shared.

Liability issues also prove a challenge for further digitalisation. After all, if tools and applications are used more intensively, the impact in case of failure grows. Therefore it is important to have a clear framework for who is liable for damages flowing from these failures. However, this liability framework in ports remains unclear, especially for AI systems. Similar problems can arise in the sense of cyber security. After all, ports are a key part of the supply chain. Cyber security Directive NIS 2 currently applies to maritime ports. However, it does not see upon inland ports- which are thus again faced with a gap in the regulatory framework.

It seems clear that the regulatory framework of inland ports regarding digitalisation is at the moment sub-optimal. Addressing regulatory fragmentation, enhancing data sharing frameworks, clarifying liability regimes, fortifying cyber security measures, and fostering innovation while ensuring

compliance are essential steps toward achieving a harmonized, secure, and efficient digital future for European ports. When updating or lining-up the framework, regulators and policy makers should keep in mind the need for standardisation and the need for a balance between regulation and innovation so that regulation does not stand in the way of further uptake. Furthermore, ports require more support from EU and national transport policies to foster development and management. This includes establishing a proper legal framework with mandatory requirements and incentives for digital infrastructure improvements.

4.2 Financial gaps and barriers

Financial issues play a large role in reducing uptake of digital tools in inland ports. This issue is not that these tools are costly (although they may well be so), but that port authorities often lack the budget to implement them. Furthermore, the financial structure of port management and the financial benefits of the port are often less well understood by local municipalities managing ports. Therefore, the benefits of digitalisation are often not seen as well, with evaluation of digitalisation options focussing mostly on their costs.

The main issue is the organisational nature of inland ports. Inland ports are mostly owned and operated by local municipalities. Since municipalities have many other responsibilities of more direct visibility to their inhabitants (i.e. the voters in the next local elections) or that are mandated by higher governments, port management often receives lower priority. This means that budgets for staffing, maintenance, overall management and innovations is usually low or hard to find. Even though subsidies exist, not all contacted inland ports were aware of which subsidies exactly suited their needs.

Both the survey and the interviews pinpointed financial gaps and barriers to be influential in the decision making process regarding further implementation of digital tools and applications. The category of financial gaps and barriers is responsible for many other gaps and barriers, listed in the categories hereunder.

The cause for this might be directly linked to how municipalities view the ports they (have to) manage. Flowing from interviews and survey came an image of municipalities having little to no attention and understanding of the importance of ports for local, regional and national economies. That a port creates added value, jobs and decreases overall emissions and road congestion is something that is easily overlooked from the point of view of a municipal government that primarily sees its own existence tied to servicing the inhabitants of its specific local geographic extent. Especially when benefits of the port are for a small or larger part often reaped outside of the geographic municipal borders as well. This can lead to the stance that a port should cost as little as possible and bring in as much revenue as possible. When a municipality has the budget to do so, the opportunity of increasing revenues may see them managing the port decently- perhaps even with digitalisation steps if those can decrease costs and/or improve revenue. Municipalities that lack any budget to do so, or simply do not have the necessary knowledge in house to realise the possibilities might very well focus on decreasing costs alone. Which leads to lower chances for digitalisation.

More funding for digitalisation of inland ports could be directly obtained through subsidies or programmes from the EU or member states. However, a more constructive solution would be to change the way inland ports are viewed by their municipalities. How to do this is not a question that could be totally answered in this research. An interesting outcome however was that a time of crisis could act as a wake up call. One interviewee clearly linked the start-up of its Communal Porth Authority Body with a critical failure in a local lock. Distress-calls from vessel owners, companies in ports and regional companies dependent on the (due to the failure unreachable) ports found their

way to local politics and policy makers. This led to all local municipalities with ports “behind the lock” to team up for communication with the national government branch in charge of repairing the lock. After the lock was repaired indeed, this collaboration was continued and grew over the years into a true communal port authority body. This example clearly shows that when local policy makers are presented with the impact a port has on the local economy, they are able and willing to act. Therefore, even without a direct crisis, such joint lobby action by the entire supply chain seem to have a chance at generating the desired change.

4.3 Technical & Functional gaps and barriers

Desk research, interviews and the survey results have sketched a clear image of the technical functionalities available on the market as digital tools and applications. In principle, basic needs for ports are covered by available digitalisation options on the market, although not always implemented by all ports because of a plethora of reasons. However, gaps in availability of digitalisation solutions for less basic needs such as energy management, emission data platforms have been identified. Survey respondents and interviewees pointed out that these areas were not yet sufficiently covered by on the market tools and applications.

A lack of standardisation and interoperability in available digital tools and applications was marked as a significant barrier for further digitalisation uptake. Current systems, tools and applications work decently to very well, but communication between them is often hard since there is a wide range of options available and different ports often use different systems. Together with supply chain stakeholders that also have a wide range for their digital systems available, getting all these systems to interconnect and communicate is a challenge. Since further digitalisation uptake often includes communication between systems of different ports and supply chain stakeholders, the fragmentation of systems in use, or the lack of standardisation in used systems, is a barrier.

Data quality is an addition to the above. Sensor data should be high quality and correctly calibrated, or it will be hard to use this for decision making. Sensor data is especially important for the step towards emissions monitoring, which is becoming relevant for inland ports in the light of the emission reduction targets. Furthermore, a regional divide in the progress of digitalisation is hindering a standardised approach: if not all regions are on the same starting level, they will have a harder time harmonising future digitalisation.

Another barrier leads to increased costs of digitalisation efforts. The realisation that digitalisation is an ongoing process and that selecting the right technologies that are scalable, compatible with existing systems and secure is a complex task is starting to take hold of inland ports. Further, continuous monitoring, feedback collection and improvement of systems is often necessary. This often means an ongoing cost. Examples of the ongoing process include the case that many systems in place for basic digital tasks are not suitable for interoperability with systems needed for the next steps. Therefore, these (often older) systems need to be replaced before next digitalisation efforts can be undertaken. This clearly increases the costs of digitalisation, and makes digitalisation more challenging to implement.

Manual input of data is an issue brought up by one of the projects evaluated. In many instances where systems such as Port Community Systems or Logistic Single Window platforms are used, data is still entered manually. This can be seen as a limit on efficiency in these cases.

The cyber security risk also makes its appearance as a technical barrier. With increasing reliance on digital systems, ports are more vulnerable to cyberattacks. These threats, including data breaches, hacking, and ransomware, pose significant risks to port operations. Robust cyber security measures,

such as firewalls and encryption protocols, are essential to protect sensitive data. These measures however are also representing extra costs of digitalisation and require skills to implement.

Collaboration issues represent the fact that private and public sectors often do not collaborate and share data in an optimal way. This is a barrier for uptake of further digitalisation since it will hinder the optimal usage of systems put in place to make the supply chains run more efficient.

4.4 Human Resources / Workforce Related gaps and barriers

Digitalisation and the implementation of digital tools and applications requires a workforce skilled in the operations and management of the digital systems. Digitalisation projects demand specialised skills and resources for the planning, implementation and operation phases. Training and development of such a workforce is of key importance. However, results flowing from the survey and desk research clearly show that the workforce capacity to execute digitalisation projects is not always adequate. A shortage of (correctly trained) staff is a significant barrier to further digitalisation.

Barriers mentioned above (cyber security concerns, regulatory fragmentation, the ongoing nature of projects and monitoring needs are some examples) increase the specialised demands on the workforce handling digitalisation projects and day to day management in inland ports. Personnel with the correct mix of skills will be in high demand also from other employers, relating to both higher personnel costs and a higher probability of staff shortages.

Although clearly linked with financial barriers, organisational aspects of the workforce are also a barrier. In many instances, municipalities with ports do not have a port-focussed division, but rather the responsibilities related to port management are spread out over multiple divisions (a few examples are the local tax division for the port dues, road maintenance division for maintenance issues, enforcement division for enforcement of port regulations). This makes it harder for employees to build up port-related knowledge and skills since the port is only one of many responsibilities for them. Similarly, there is no central point of knowledge with overview about all aspects related to the port within the workforce. Typically, a municipality that is organised like this will have a hard time implementing digitalisation measures.

5 Conclusions

This report analysed the gaps and barriers affecting the development and implementation of digital tools. The means of analysis were a desk research coupled with a thorough literature review, a survey with over 30 responses and a small number of interviews targeting interviewees representing multiple inland ports.

The analyses identifies a significant amount of gaps and barriers that stand in-between European inland ports and (further) uptake of digital tools and applications. Digitalising this sector will be challenging because of the generally low level of budgets locally available for inland port management, standardisation and interoperability problems between the systems currently in use, a fragmented and not fully covering legal framework, and a shortage of qualified staff to implement the necessary changes. Especially the organisational nature of many inland ports within local municipal governments, often with fragmented responsibilities of different port management tasks over municipal divisions and little to no specific port staff appointed, contributes to these barriers. This problem is rooted in the non-understanding of local politicians and policy makers of the socio-economic impact that local ports have to the local and wider community . Furthermore, local inland port managers that want to implement digitalisation steps are missing clear guidance from regional, national and European government levels and are sometimes struggling to find their way to the best available support schemes.

Analysis of the gaps and barriers found clearly showed their spread over the areas legal, financial, technical and workforce related. The gaps and barriers per theme are discussed in more detail in the chapter above, but hereunder the most important ones are summarized.

Legal

- Fragmentation of the legal framework: hard to navigate;
- No legal standardisation of systems to use: plethora of systems in use;
- Clear gaps in the legal framework regarding liability issues: no coverage of cyber security legislation for inland ports;
- Overall liability challenges: unclear, no standardised solution;
- Data security regulations are a barrier for data sharing: harder to implement some digital innovations;
- No rule-out of the non-digital option: systems and personnel to service non-digital way of operation cannot be removed. Costs cannot be saved.

Financial

- Lack in available budgets for managing inland ports, and thus for digitalisation: due to a lack of understanding of local policymakers and politicians regarding the benefits of inland ports;
- Organisational fragmentation: due to the same issues as the bullet above, co-resulting in budget issues and unclarity;
- Subsidy framework is unclear and not always easily navigable.

Technical

- Port management needs for greening/modernisation not yet fully covered;
- Lack of standardisation in systems: reduced interoperability;
- Age of systems in place: not always suitable for interoperability with more innovative systems;
- Data quality is an issue: e.g. emissions monitoring is hampered by this;

- Regional non-harmony: differences in digitalisation ‘level’ between regions, difficult to standardise or navigate for region-crossing operators;
- Manual data input still in use: reduction in efficiency of systems and increased risk of human error;
- Cyber security is an ongoing area of concern: solutions require continuing attention and budget.

Workforce

- Capacity in the workforce is a gap: not enough skilled personnel available for all port management and digitalisation needs;
- Barriers such as cyber security, legal barriers and others mentioned above only increase the skill-level needed by the workforce;
- Organisational gaps: often there is no single port division but a fragmentation of port related responsibilities over multiple divisions;
- Organisational gaps: (related to the above) staff is often not port-specialised but has many other areas of responsibility.

Having thus summarised the gaps and barriers, this report leaves a clear starting point for the work in the sixth subtask of the digitalisation task of Green Inland Ports. Here, among other things, a number of recommendations to overcome these gaps and barriers will be set up and a roadmap for digitalisation of inland ports will be made.

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