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Increasing Resilience of Intermodal Freight Transport Networks – Key Challenges in Disruption Handling and Requirements for Digital Solutions

John von Stamm, M. Sc.[1], Alina Behle, M. Sc.[1] and Jonas Dallwig, B. Sc.[1]

1. FIR at RWTH Aachen University, Aachen, Germany

Corresponding author: john.vonstamm@fir.rwth-aachen.de

Abstract: The Eurozone faces growing economic and environmental challenges, with supply chain disruptions causing losses of over EUR 112.7 billion in 2021. Climate change, geopolitical risks, regulatory shifts, and infrastructure weaknesses strain intermodal freight transport, highlighting the need for digital solutions to enhance resilience and efficiency.

This paper examines key challenges in intermodal freight transport, including disruption triggers, network vulnerabilities, and inefficiencies in disruption management. Extreme weather, and capacity shortages impact both performance and sustainability. Using the Total Quality Framework (TQF), the research includes interviews with 23 stakeholders from 10 countries, focus workshops, and surveys. The analysis reveals shortcomings in real-time data integration, interoperability, and disruption response. Regulatory fragmentation and low digital maturity hinder resilience strategies. Addressing these gaps requires harmonized data frameworks, improved interoperability, and the use of collaborative digital platforms.

The Horizon Europe project ReMuNet leverages intelligent algorithms and digital platforms to enhance multimodal networks, optimize route planning, and improve disruption response, contributing to the vision of the Physical Internet.

Keywords: Physical Internet, Supply Chain Resilience, Disruption Management, Intermodal Freight Transport, Digital Logistics Platforms, Sustainable Logistics

Physical Internet (PI) Roadmap Fitness: ☐ PI Nodes (Customer Interfaces, Logistic Hubs, Deployment Centers, Factories),☐ Transportation Equipment, ☒ PI Networks, ☒ System of Logistics Networks, ☐ Vertical Supply Consolidation, ☒ Horizontal Supply Chain Alignment, ☒ Logistics/Commercial Data Platform, ☐ Access and Adoption, ☒ Governance.

Targeted Delivery Mode-s: ☒ Paper, ☐ Poster, ☐ Flash Video, ☒ In-Person presentation

1 Introduction

The Eurozone faces growing economic and environmental challenges, with supply chain disruptions causing losses exceeding EUR 112.7 billion (Ollagnier et al., 2022). Climate change-driven disruptions are increasing, forcing companies to prioritise resilience (Bocksch, 2020; Brandt, 2021).

This paper builds on insights from the Horizon Europe project ReMuNet – Resilient Multimodal Freight Transport Networks, which enhances resilience, sustainability, and adaptability in logistics using digital technologies. It promotes standardisation, collaboration, and SME integration, fostering a more connected and sustainable freight network (von Stamm et al., 2024). Organisational challenges and low digital maturity hinder disruption management, causing delays and financial losses. Strengthening resilience requires robust systems, flexible responses, and adaptive learning. This paper assesses the current intermodal freight ecosystem, identifies challenges, and outlines digital solutions to enhance resilience.

2 Background Information and Definitions

2.1 Resilience of Freight Transport Networks

The term "resilience" originates from the Latin word "resilire", meaning "to rebound" or "to spring back". It is generally defined as the ability to quickly return to a previous positive state after encountering problems (Cambridge Dictionary, 2024b). "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973). A resilient system can absorb disruptions, adapt to changes, and recover quickly while maintaining its core functions (Clement et al., 2021; Holling, 1973). Key characteristics include adaptability, flexibility, agility, redundancy, robustness, and learning (De Marchi et al., 2023; Morisse and Prigge, 2017). Resilience focuses on short-term functionality and recovery, complementing long-term sustainability goals (Brundtland et al., 1987). In the context of freight transport, "a resilient freight transport network minimises disruption-related impacts on network performance in terms of both intensity and duration, along with minimising the system recovery time" (von Stamm et al., 2024).

2.2 Disruptive Events in Intermodal Freight Transportation

Since resilience refers to the ability to recover from a disrupted system state, a "disruption" can be defined as an "action that prevents something, especially a system, process, or event, from continuing as usual or as expected" (Cambridge Dictionary, 2024a). In relation to the logistics sector, a disruptive event can therefore be defined as any planned or unplanned interruption or change to the operation of a transport network that causes effects such as delays, blockages or closures (Schiffling et al., 2024). The effects of these disruptive events can vary in terms of geographical extent and duration. Depending on their operational focus, disruptions can occur in the physical infrastructure, but also at the interface between the physical infrastructure and the information level where (digital) information exchange happens (Schiffling et al., 2024). Disruptions can be categorised into nine dimensions shown in figure 1.

Natural Disaster	Technological Failure	Regulatory Changes	Security Incidents	Accidents
• Earthquake • Flood	• Power Outage • Signal Failure	• Customs Procedures • Environmental Regulations	• Cyber Attack • Terrorism	• Road traffic Collision • Derailment
Health Emergencies	**Capacity Shortages**	**Geopolitical Crisis**	**Extreme Weather**	**Economic Slowdown**
• Human Pandemic • Animal Disease	• Truck Driver Shortage • Infrastructure Constraints	• War • Trade Dispute	• Drought • Extreme Cold	• Recession • Low Consumer Confidence

Figure 1: Categories of Disruption and its causes (based on Schiffling et al., 2024)

2.3 Freight Transport Modes

The "transport mode refers to the way in which […] goods can be transported" (European Commission, 2025). Multimodal and intermodal transport both involve multiple transport modes but differ in the coordination and management of these modes. Multimodal transport refers to the movement of goods using at least two different modes of transport under a single transport contract (Gronalt et al., 2019). In intermodal transport on the other hand each transport segment has to be organised with an individual contract (Rodrigue, 2018). In practice, the first and last legs are typically handled by road freight, the main leg by mass transport modes like rail or ship, with terminals serving as transfer points. In this paper, both terms are considered interchangeable when discussing the combination of different modes of transport.

2.4 Solution Hypothesis

The authors hypothesise that contributing to network resilience while maintaining sustainability can be achieved by optimally leveraging the strengths of different transport modes in intermodal freight transport networks. A significant contribution can be achieved by leveraging digital technologies, such as the Physical Internet (PI), to enhance responsiveness and adaptability, enabling improved cross-stakeholder communication and fostering collaborative solutions.

3 Methodology

This research applies the Total Quality Framework (TQF), a comprehensive approach ensuring valid and useful qualitative study designs (Roller and Lavrakas, 2015). TQF follows three phases: Data Collection, Analysis, and Reporting (figure 2).

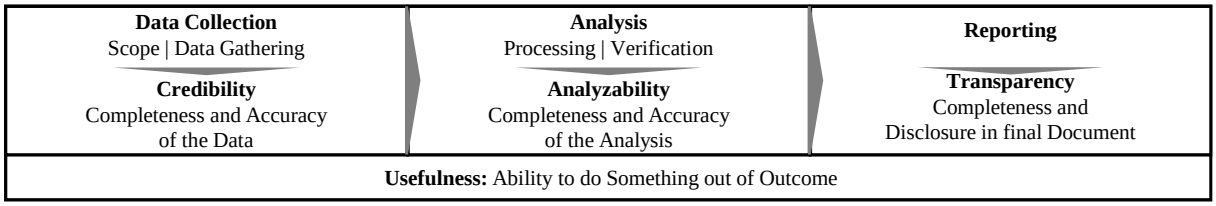

Figure 2: Total Quality Framework (based on Roller and Lavrakas, 2015)

3.1 Data Collection

The scope of this research is to identify key disruption triggers and their impacts on the intermodal transport network. With further consideration of the existing challenges in the logistics industry, requirements are first derived from the findings of the disruptions and challenges. These are then used to identify potentials for intermodal network resilience. For this purpose, semi-structured interviews and workshops were conducted with 23 key stakeholders from ten European countries, including (digital) logistics service providers, carriers (road, rail, inland waterways), freight forwarders, multimodal operators, and terminal operators (see Annex I). An online survey complemented the interviews, validating key aspects (see Annex II). Both methods focused on four main topics (table 1): stakeholder profiles, logistics disruptions, industry challenges, and potential solutions or requirements.

Table 1: Topic specific question focus

General	What are the main activities of the company and what are its economic key value propositions?
	Which customer segments does the company serve and what data is exchanged?
Disruptions	Which disruptions affect the company the most or most frequently and what challenges does it face in overcoming them?
Challenges	What are the main challenges that the company faces in its operations and how have they been addressed so far?
Needs and Requirements	How can digital solutions contribute to better disruption management and what has hindered implementation so far?

3.2 Analysis and Reporting

After data gathering, statements were analysed using an inductive approach. Thematic analysis identified recurring issues, providing a structured yet flexible interpretation. Results were systematically structured within the research framework. Disruption triggers, impacts, and challenges were analysed, leading to derived needs and requirements. Finally, potentials for enhancing intermodal transport resilience were identified. Informed consent was obtained, and confidential disclosures were excluded, ensuring ethical integrity and trust.

4 Disruptions in Intermodal Transport

The triggers for disruptive events identified in the expert interviews and workshops were analysed considering the categorisation of Schiffling et al. (2024). Impacts were mapped to the elements of the transport network, depending on whether a disruption affects a node, an edge or the entire network (figure 3).

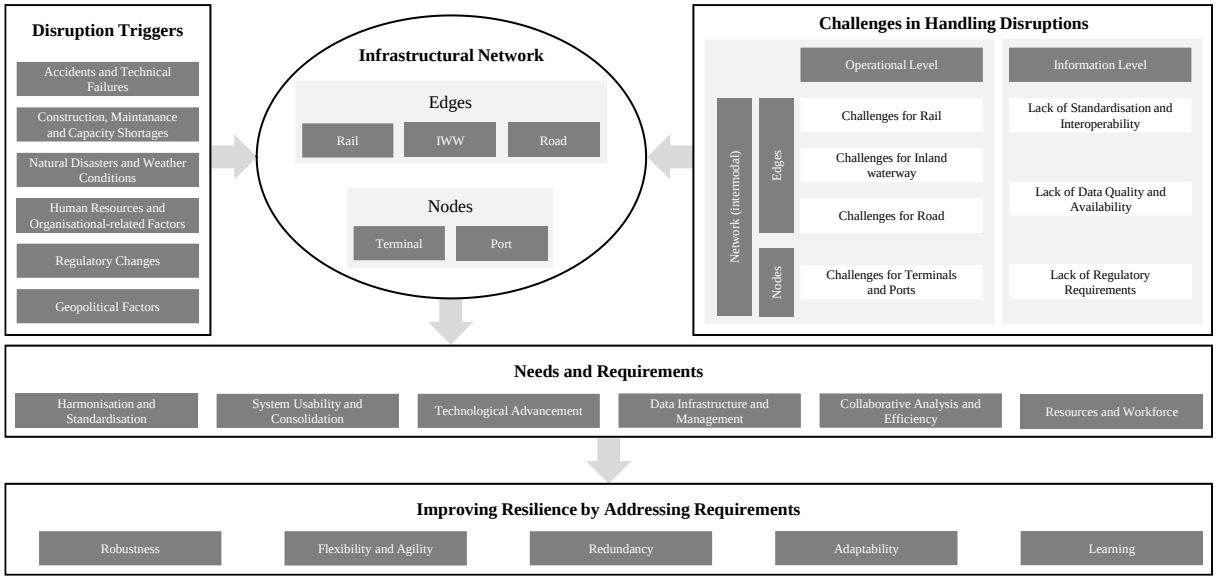

Figure 3: Key Challenges in Disruption Handling and Requirements for Digital Solutions

Physical infrastructure triggers include accidents and technical failures like signal or point malfunctions, causing closures and reduced capacity, especially in rigid systems such as rail and inland waterways (IP 3, 9, 13, 16). Construction and maintenance often disrupt operations through delays, line closures or port congestion (IP 16, 19). Capacity is further strained by equipment damage or staff shortages (IP 9, 16). Natural disasters are increasingly disruptive due to climate change (IP 8, 9, 13). **Organisational triggers** stem from human resource issues like strikes or protests, blocking key routes and terminals (IP 16). Geopolitical factors such as conflicts, sanctions, or political shifts hinder corridors and impair infrastructure, as seen in the Ukraine war and tensions in grain trade (IP 4, 16). Non-EU memberships or diverging policies interrupt inland waterway continuity (IP 6). Regulatory disruptions arise from shifting legal frameworks, inconsistent border checks or trade rules, causing inefficiencies (IP 6, 16). For instance, COVID-19 restrictions heavily limited road freight, while Brexit added customs delays (IP 15, 9)

5 Challenges for Intermodal Transport Stakeholders

Beyond disruptions, various challenges hinder transport efficiency and resilience. Challenges specific to edges, nodes, and the network are analysed, along with those related to information standardization, interoperability, data quality, and regulations (figure 3).

5.1 Challenges affecting Edges

5.1.1 Rail Transport

The rail network is highly **inflexible**, making re-routing difficult during disruptions, which often escalate quickly into widespread delays and congestion (IP 3). A single incident can trigger cascading effects, and restoring normal operations takes significant time: “If there's a disruption during transportation, it has a huge impact on the entire transport network. […] The problems scale up to even bigger problems in a very short time […] it takes a long time to get the systems back to normal operation.” (IP 3). **Capacity** is already exhausted leaving no room

for additional freight or surges in demand, underscoring the urgent need for infrastructure upgrades (IP 5). According to IP 5 „the rail is completely utilised; you can't put any more on the rail at the moment" (IP 5). Cross-border transport is further complicated by **regulatory fragmentation and the lack of interoperability**. Unlike road freight, rail requires country-specific locomotive licenses, driver certifications, and language skills, which add complexity and reduce competitiveness (IP 16). Inconsistent train identification also poses a barrier as operational train numbers differ between operators and countries, making tracking difficult (IP 12). A unified European train ID has been proposed to address this, but no solution has yet been implemented (IP 12).

5.1.2 Inland Waterway Transport

Inland waterway transport suffers from **restricted flexibility** due to its fixed infrastructure and closed system design (IP 3). Waterways offer less adaptability than road transport, as vessels cannot deviate freely or dock anywhere. They rely on ports and locks as access points, limiting operational flexibility (IP 3). This strict **reliance on existing structures** renders the system vulnerable to disruption and delay. In the event of unforeseen circumstances, such as technical failures, flooding or low water levels, it is not possible to divert ships at short notice. This restricts the ability to react and makes operations more challenging (IP 3). **Outdated infrastructure** is a major obstacle to inland waterway transport (IP 3). Many locks, signalling systems, and draught measures are no longer fit for purpose and lack proper maintenance or modernisation (IP 3). The **coordination of international efforts** is a major challenge for cross-border waterways: "The issue for us is not only that the […] national territory plays a role in navigability, but also all the downstream member states" (IP 6). Varying regulations and infrastructure conditions across countries, especially on waterways like the Danube, make reliable navigation dependent on political decisions downstream (IP 6).

5.1.3 Road Transport

The reliance on road transport as a **contingency for rail transportation** presents challenges (IP 8). Rail disruptions drive up road demand, requiring up to three times more lorries. This shift strains capacity and hinders sustainability (IP 8), as road transport emits 7.5 times more greenhouse gases per ton-kilometre than rail (Statista, 2024). Road transport is highly sensitive to **fluctuations in the economic cycle** (IP 2). During downturns, increased supply lowers transport prices, drawing customers from rail to road. Road freight's price sensitivity makes it less stable and more vulnerable to short-term economic shifts (IP 2).

5.2 Challenges affecting Nodes (Terminals/ Ports)

Capacity bottlenecks often emerge at these nodes rather than along the transport routes (IP 19). When terminals become congested, cargo cannot be moved in or out efficiently, limiting the system's overall performance. **Slot management** is another major issue. Terminal time slots are not integrated into the centralized rail network and remain uncoordinated by infrastructure providers (IP 2). Although IP 12 emphasizes the need to align terminal slots with main transport routes, such harmonization is difficult due to jurisdictional limitations (IP 12). Delays or train cancellations at terminals reduce resource utilization and trigger knock-on effects across the entire network (IP 3). **Coordination and communication** gaps further affect efficiency. While construction and maintenance projects are announced in advance, their full implications are not always clearly communicated (IP 2). IP 21 also notes unrealistic expectations during planning: companies often place orders without understanding operational constraints, leading to misalignment and frustration when outcomes fall short of expectations. Finally, **regulatory and administrative issues** add to the strain. Missing documentation or import permits can hold up containers in ports, resulting in delays and costly demurrage fees (IP 4).

5.3 Challenges on Network Level

The intermodal nature of modern logistics networks brings flexibility but also creates **dependencies** that can amplify disruptions. Smooth operations rely heavily on infrastructure managers, whose response speed is crucial during disruptions: “We are massively dependent on the reaction speed of the infrastructure operators” (IP 16). Delays in restoring services can cause cascading effects across transport modes, highlighting the need for coordinated and timely responses to ensure network resilience. Moreover, **capacity limits**, particularly at ports, have network-wide implications. When ports reach full capacity ships queue outside ports, and logistics providers struggle with unreliable schedules (IP 19). During peak periods, this can significantly reduce overall productivity as transport plans become unreliable and challenging to plan: “There might be capacity available [on other modes of transport], but smooth access to that is in most cases the most challenging thing” (IP 8). Gaining access often requires complex coordination and extensive negotiations with partners, while rising demand during disruptions aggravates the situation (IP 8). Furthermore, there is an **insufficient level of redundancy** regarding modal shifts in intermodal transport (IP 9). Although resilience through modal shifts is desired, it is rarely feasible in practice: “That sort of resilience is wished for today. But unfortunately, I should say it is not available” (IP 9). The capacity of the rail network is frequently constrained, with freight transport frequently receiving a lower priority than passenger transport. In the absence of redundant infrastructure, intermodal logistics is unable to provide reliable alternatives for affected cargo (IP 9). Furthermore, the lack of redundancy is intensified by the **inflexibility of inland waterways and rail systems** (IP 3), as both inland waterways and railways are closed systems with limited flexibility. This results in a significant impact even from minor disruptions, which often spread across the entire network and create broader operational challenges that require a considerable amount of time to resolve (IP 3).

5.4 Challenges on Information Level

In addition to the challenges of the transport network at the infrastructure and organisational level described above, there are also numerous challenges at the information level. These challenges affect the entire network and impair the efficiency of key transportation processes.

5.4.1 Lack of Standardisation and Interoperability

The **fragmentation of standardisation among stakeholders** hinders interoperability, efficiency, and transparency in freight transport (IP 11). Different modes follow separate standards without a harmonised framework (IP 7), making integration complex and costly (IP 7, 9, 21). Furthermore, SMEs struggle with limited resources to meet complex standards (IP 22) although, according to the survey, data standardisation and automation is the most important requirement among SMEs. Only 43% of stakeholders use standardised data exchange formats. Therefore, basic functions like appointment scheduling and cargo visibility suffer from missing communication protocols, causing inefficiencies (IP 14). Efforts toward standardisation are further hindered by national regulations and diverse systems (IP 12), forcing bespoke integrations (IP 19). Furthermore, **system incompatibility and interoperability issues** disrupt data flow and visibility (IP 7). Outdated systems and varying software setups block modern API use (IP 15), and manual interfaces and incompatible logic reduce efficiency (IP 11, 16, 19). **Data exchange format fragmentation** further leads to inconsistent formats, manual mapping, and compliance issues (IP 12, 13, 19). Legacy systems like EDI are still widespread (IP 3). **Manual data handling and transfer** causes inefficiencies, delays, errors, and limited automation due to media breaks and missing protocols (IP 2, 14, 19). Finally, **system diversity** results from customised IT systems (IP 11). Even identical software differs across users (IP 6, 11, 21), creating “many parallel [non-interoperable] systems” (IP 6).

5.4.2 Lack of data quality & availability

Inaccurate and inconsistent data affect operational efficiency, planning, and decision-making. Data quality issues often arise from incomplete, outdated, or misaligned information, (IP 3, 7, 14, 15): “This kind of data lead to errors in documentations, sometimes in misinterpretations, and subsequently to the delays” (IP 13). Further, **unreliable and incomplete tracking information** limits shipment visibility due to real-time data gaps and inconsistencies between transport modes, reducing the reliability of tracking systems (IP 7, 8, 14). Challenges with **data availability** arise from issues of data quality, access and reliability. Inconsistent data disrupts forecasting, especially for medium- to long-term planning (IP 7). Administrative barriers and unreliable communication with stakeholders increase uncertainty (IP 22). **Barriers to data sharing and transparency** weaken efficiency and digital adoption. Many stakeholders hesitate to share data due to trust, confidentiality, or control concerns (IP 1, 2, 11, 12, 19, 22). As a result, decisions rely on outdated or planning-only data, limiting real-time insight (IP 11). **Manual processes and the lack of automation** remain widespread. Despite AI advances, manual effort dominates, especially in document handling, which is still often paper-based, increasing inefficiencies and system fragility (IP 3, 8). **Route planning and rerouting** suffer from unreliable data, lack of transparency, and limited alternative options during disruptions. Inadequate planning data and poor stakeholder coordination therefore make adjustment measures difficult, increasing delays (IP 1, 8, 11, 14). **Capacity planning** is challenged by inaccurate data and fluctuating demand (IP 1, 2). Planners often operate under the assumption of unlimited capacities, which leads to inefficiencies and suboptimal decision-making when actual constraints emerge (IP 1).

5.4.3 Lack of regulatory Requirements

Complexity and frequent changes in regulatory frameworks burden the transport sector through excessive bureaucracy, frequent adjustments, and resource-intensive compliance (IP 13, 22). Legal complexities slow operations and discourage innovation, especially for those unfamiliar with the regulatory environment, reinforcing reliance on traditional methods (IP 7, 13). This constant need for vigilance drains resources and reduces the sector's efficiency (IP 13). **Uncertainty about future regulatory decisions** makes long-term planning difficult. Operators often cannot foresee upcoming regulations, increasing risk and complicating strategic decisions (IP 7). The **lack of harmonisation in cross-border regulatory frameworks** further creates inefficiencies due to inconsistent national standards. Border disruptions, unclear responsibilities, and unpredictable customs decisions cause delays and operational challenges (IP 4, 8, 14, 15). Inconsistent rail processes and customs classifications further complicate international logistics. Finally, the **lack of standardised terminology and processes** hampers coordination. Varying terms for the same actions lead to confusion and inefficiencies: “different terms for the same action bring in a lot of challenges” (IP 9)”. The absence of universal standards increases integration costs and limits interoperability (IP 7, 9). Even within the EU, inconsistent documentation standards result in outdated and inefficient cross-border procedures (IP 14).

6 Needs and Requirements to improve Disruption Handling

The disruptions and associated challenges in combined transport give rise to specific needs and requirements that aim to increase the resilience of the transport system. These requirements are divided into six central categories: harmonisation and standardisation, system usability and consolidation, technological advancement, data infrastructure and management, collaborative analysis and efficiency, and resources and workforce (figure 3). **Harmonisation and standardisation** are key to improving resilience in combined transport. Stakeholders call for

uniform terminology, data formats, and interoperable systems to enable efficient collaboration (IP 9). Revised rerouting regulations and standardised crisis procedures, including clear rules for prioritisation, can enhance coordination in emergencies (IP 8, 22). The establishment of a neutral platform could prove to be a pivotal element in this process, as clear rules regarding the prioritisation of entities in exceptional circumstances has the potential to mitigate the negative effects of chaos and enhance the overall performance of the system (IP 22). **Data infrastructure and management** is crucial for flexibility and transparency. A neutral, accessible data pool enables informed, real-time decisions (IP 1, 14, 18). To this end consistent end-to-end data improves transparency across supply chains (IP 14), while automated data exchange reduces inefficiencies and enables faster responses to disruptions (IP 9, 13). IP 5 explains that real-time data is "essential" to respond flexibly to disruptive events. AI-based systems and predictive models, as proposed by IP 9 and IP 13 enable the development of alternative plans at an early stage. These forward-looking approaches allow risks to be better managed and decisions to be made on a more informed basis (IP 18). A unified interface for all stakeholders would further boost integration (IP 12, 18). For systems to function effectively, **usability and consolidation** are key. The interviewees stress the need for consistent use of existing digital tools and for systems that are intuitive and user-friendly (IP 15). Furthermore, **collaborative analysis** enables coordinated action and improved efficiency. While many actors seek data, they often hesitate to share it. A transparent exchange where all parties contribute, and benefit is seen as a step toward mutual resilience which can only be reached by a joint discussion in which all participants transparently share their data (IP 3). Efficiency should thus be pursued as a collective aim, not just an internal one (IP 3, 5, 13). **Technological advancement** is thus central to overcoming the limitations of existing systems and to integrate the various and often complex system landscapes. This includes the necessity for real-time data availability and modern data exchange, such as the development and implementation of uniform standards that enable compatibility between old and new systems (IP 22). The interviewees therefore call for modular, integrable technologies, and long-term strategies for digital modernisation (IP 3, 22). Fear of mishandling sensitive customer data and navigating compliance requirements are significant sources of apprehension (IP 19). Therefore, the interviewees stress the need for secure cloud environments and compliance frameworks to safeguard sensitive data and build trust in digital systems (IP 13, 14, 19). However, the introduction of advanced technologies is impeded by high implementation costs (IP 13) and reservations regarding data sharing (IP 2, 3, 11, 12, 22, 22).

7 Potentials for improving Intermodal Network Resilience

Improving resilience in intermodal networks depends on strengthening robustness, flexibility and agility, redundancy, adaptability, and learning. **Robustness** involves stable structures and secure processes that absorb initial disruptions. Cybersecurity, harmonised regulations, and standardised data systems build reliability, while user-friendly information systems ensure consistent data access across stakeholders. **Flexibility and agility** enable quick reactions and fast recovery. Real-time awareness, efficient data exchange, and usable systems support dynamic rerouting during events like route closures. Advanced technologies like rerouting algorithms help maintain operations when disruptions such as route closures occur. **Redundancy** provides backup options through additional resources, infrastructure, and processes. It ensures continuity when parts of the network fail, for instance by enabling rerouting or switching between modes. A resilient network requires mature technologies, accurate and up-to-date information, and standardised communication protocols to manage disruptions without major losses. **Adaptability** refers to the system's ability to evolve with change. Harmonised regulations are key to allowing controlled adjustments without causing

further fragmentation. Adaptability ensures that networks can respond not only to one-time disruptions but also to long-term shifts in conditions or requirements. **Learning** from disruptions is essential to build future resilience. This involves collecting data, applying standardised analysis methods, and using advanced digital tools to identify causes and improve preparation. Staff training and consistent equipment maintenance are basic requirements for embedding resilience in practice. Recovery must be followed by collaborative evaluation processes to strengthen response strategies over time.

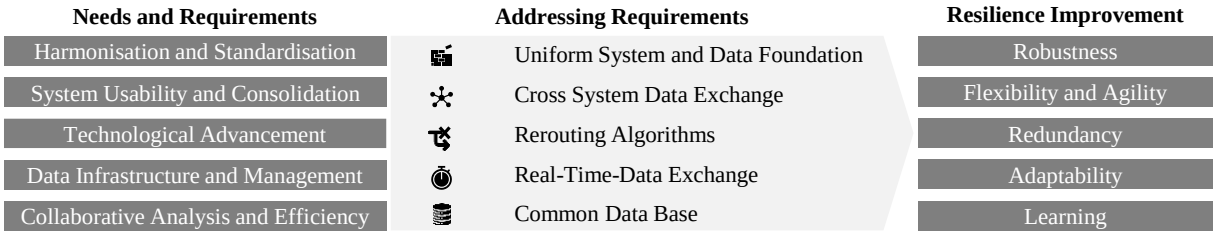

Figure 4: How addressing needs and requirements can improve resilience

Pursuing the same long-term goal digital technologies in multimodal transport not only improve resilience but also environmental sustainability by optimising operations, reducing emissions and promoting resource efficiency.

8 Conclusion and Implications for future Research

The growing economic and environmental pressures within the Eurozone underline the urgent need for more resilient and efficient intermodal freight transport systems. This paper highlights a broad range of vulnerabilities that currently undermine resilience, including the increasing frequency of extreme weather events, infrastructure bottlenecks, geopolitical instability, and low levels of digital integration. These factors not only impair performance but also limit the sector's ability to respond flexibly to disruptions.

Several key challenges were identified: outdated and inflexible infrastructure, lack of redundancy, regulatory fragmentation, and an insufficient level of digital maturity across stakeholders. Furthermore, the absence of standardised data formats, poor interoperability, and limited real-time data availability severely hinder effective disruption management. Manual processes, fragmented IT landscapes, and a general lack of trust and transparency in data exchange amplify inefficiencies and prolong recovery times during disruptive events.

To address these challenges, the study derives concrete needs and requirements: harmonised and standardised regulatory and data frameworks, usable and consolidated systems, technological advancements, improved data infrastructure and management and enhanced cross-stakeholder collaboration. Real-time data exchange, a common database for cross-system data exchange, predictive analytics, and AI-supported rerouting tools emerge as key enablers of a more agile and responsive transport system.

These findings align strongly with the long-term vision of the PI, promoting a modular, standardised, resilient and digitally interconnected logistics ecosystem and transforming today's fragmented transport systems into open, interoperable networks. Increasing resilience of intermodal freight transport networks is not only a response to today's disruptions but also a decisive step toward building the PI.

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During the preparation of this work the authors used DeepL and ChatGPT4o to improve the readability and language of the manuscript. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Appendix

Annex I: Detailed Interview Partner List

IP	Role & Nationality	Business Activities	Why the Interview partner was selected
IP 1	4th Party Logistics Service Provider DLSP *Germany*	Optimisation service provider specialising in road transport, offering solutions to improve customers' transportation, warehousing, and handling processes, with a focus on transparency through their TMS platform	This company is a leading global provider of supply chain consulting, software, and fourth-party logistics (4PL) services. Insights on end-to-end logistics processes and technical requirements are especially relevant for the stakeholder analysis
IP 2	Terminals *Luxembourg*	Multi-use terminal operator managing train operations, container trading, and employing sustainable practices, including renewable energy and battery electric vehicle	This operator of a public intermodal terminal in Luxembourg can handle all intermodal transport units on an area of 33 hectares and uses innovative technologies like AI-applications to increase the efficiency of transshipment processes. The company offers valuable insights from the perspective of terminal operators and provides suggestions for the use of digital technologies.
IP 3	Carrier Terminals Infrastructure Manager/Operator *Germany*	Trimodal logistics company, specialising in container import/export via inland waterway, rail, and trucking, with a network of terminals across Europe	This company specialises in trimodal transportation connecting seaports with the European hinterland moving an annual freight volume of 2.1 million TEU within its network along the river Rhine. This partner therefore offers crucial industry information along all transport modes.
IP 4	NGO (Humanitarian Logistics) *Denmark*	Providing auxiliary support, coordinating logistics operations, and establishing warehousing hubs for efficient disaster response and conflict management	One of the largest humanitarian networks worldwide provides aid support to people affected by conflicts or disasters. Their extensive expertise in the field of humanitarian logistics contributes fundamentally to understanding the challenges and requirements of aid organisations in freight transport logistics.
IP 5	DLSP *Germany*	Digital logistics service provider specialising in road freight optimisation and additional services, (with potential for multimodal transportation)	This software-SME is one of Germany's most innovative logistics tech start-ups and has access to an extensive network of freight forwarders and transport companies. Their multi-tenant matching platform enables conducting event-based relay transports to circumvent disrupted infrastructure sections.
IP 6	Infrastructure Manager/Operator *Austria*	Operating an infrastructure provider, with a primary focus on container handling at a terminal, emphasising various modes of transportation and collaborating on urban logistics initiatives with an academic institution	This stakeholder operates one of the most important inland ports in the Rhine-Danube corridor and handles around 1200 cargo ships per year. The company offers a comprehensive service portfolio and has access to a large network of the most important hinterland logistics companies in Europe.
IP 7	Software Provider *Germany*	Providing logistic planning products, including route and tour planning, load optimisation, geo-management/geo-marketing solutions, intermodal component solutions, and customised software-as-a-service options for automated tour planning and delivery time estimation	As a European market leader in traffic and transport route planning. In addition, the company is involved in many innovative projects to further develop its state-of-the-art software solutions and support the logistics industry.
IP 8	Terminals	Creating a sustainable European network with assets like trucks, trailers, containers,	The company is one of the largest European transport companies focusing on multimodal

	Carrier *Netherlands*	vessels, and rail connections, and operating hub terminals for efficient customer service	transport by operating own terminals, transport vehicles, and loading units. This stakeholder provides crucial information on multimodal transportation and disruption management.
IP 9	Industry Association *Germany*	Promotion and development of sustainable freight transportation using different loading units, conduct research, studies, and consulting activities, and advocate for the adoption of combined transport within the freight transport sector	This partner is one of the most important non-profit membership associations in intermodal logistics. For 80 years this association has connected relevant actors of the Combined Transport sector and created a neutral communication and knowledge platform for research and development.
IP 10	Research & Consulting *Netherlands*	The establishment of an integrated grid network for supply chain partners, facilitating customisable data sharing, multimodal visibility services, and authentication-based link-driven data exchange for the generation of digital product passports.	As a leading Dutch research and consulting organisation this stakeholder holds extensive expert knowledge to facilitate seamlessly connected logistics systems that are more efficient, create new business opportunities and reduce emissions.
IP 11	Software Provider *Germany*	Digital logistics service provider offering a software for optimising transportation routes and data driven decision-making.	As a leading provider of artificial intelligence and mathematical optimisation systems, this stakeholder's software products support dispatchers and planners in calculating complex and time-critical logistics scenarios.
IP 12	Industry Association *Belgium*	Raising stakeholder awareness, consulting policy makers, and standardising combined transport operations, while representing intermodal operators as key actors in the integrated freight transport chain.	As one of the main industry associations in the European intermodal transport industry this stakeholder actively promotes Combined Transport, primarily towards European decision-makers and supports the daily functioning of this ecologically and economically sustainable mode of long-distance freight transport. The association has in-depth knowledge of existing standards, legal requirements and current challenges in intermodal transport and is familiar with the needs of its members due to its role as an interest representation body.
IP 13	Freight Forwarder *Greece*	Intermodal freight transport, facilitating smooth movement of goods across various modes of transportation, acting as intermediaries between shippers and carriers, and operating primarily in Europe	This SME freight forwarder specialises in road and sea transport organisation and provides – besides specific industry knowledge - detailed insight into the challenges faced by smaller logistics companies when implementing digital solutions.
IP 14	Software Provider Logistic Service Provider *France*	Product lifecycle software and collaborative platform provider for multiple industries, with a strong emphasis on mobility, manufacturing, aerospace, and defence.	As one of the largest software companies in Europe, this stakeholder has an extensive software and service portfolio for various industry segments. From the transport logistics perspective especially, the collaborative digital platform holds significant potential to address current business challenges in the transport sector.
IP 15	Software Provider Logistics Service Provider *Finland*	Software solutions for transparency, optimising parcel routing, acting as middleware between ecommerce stores and warehouses, and providing warehousing services for efficient picking and packing of goods	This logistics service provider helps e-commerce businesses to optimise their supply chain, speed up delivery times, and reduce costs with a modern 3PL service. With extensive experience in e-commerce shipment tracking and other logistics services this innovative SME contributes valuable information on digitalised supply chains.
IP 16	Carrier *Austria*	Rail transportation, including intermodal and wagon loading traffic	This company holds the operating licence for all railway lines in Austria and the EU. This railway undertaking operates freight transport both on its own infrastructure (with its own diesel locomotives) and on third-party infrastructure (with its own diesel and electric locomotives) and provides important information on rail cargo transports in the Rhine-Danube Corridor.

IP 17	Infrastructure Manager/Operator *Austria*	Owning and managing transportation infrastructure, including parking lots, rest areas, and rest stops, to facilitate smooth and convenient journeys for road users, particularly those engaged in road freight transportation, catering to car and truck drivers, as well as special transports	This infrastructure company is responsible for the planning, construction, operation and tolling of the Austrian motorway and motorway network. As an important road network operator in the Rhine-Danube corridor, this player supplements the stakeholder analysis with important information from the perspective of an infrastructure operator.
IP 18	Carrier Terminals Freight Forwarder *Switzerland*	Offering a cost-effective and sustainable transport chain for continental transports, utilising sea, inland waterway, rail, and road modes, optimising efficiency for longer routes, and providing cross-border transport services in Europe with seamless last-mile deliveries	This interview partner is one of the market leading combined transport operators in Europe. As a neutral combined transport operator, this company moves over 1 million road consignments annually and consolidates shipments from transport companies to complete trains utilising 9100 own wagon modules. As a major combined transport operator, this company offers important industry insights and provides significant support in identifying challenges around combined transport.
IP 19	Freight Forwarder *Switzerland*	Offering end-to-end transport solutions, including ocean freight, air freight, European land transport, contract logistics, customs services, and data management, operating as an asset-light company	This large company is the leading sea freight and air freight forwarder worldwide offering specialised transport solutions for major industries as a global logistics partner. Being one of the most important freight forwarding companies this partner provided important insights on freight transportation and the use of digital technologies.
IP 20	Consignor & Consignee *United States, Europe*	Production and distribution of consumer goods	This American multinational consumer goods corporation is one of the largest shippers in Europe and contributes important insights to the stakeholder analysis from a consignor/consignee perspective.
IP 21	Freight Forwarder *Germany*	Managing standardised transport orders, unitising them based on client software systems, handling various container types, good types, commercial types, capacities, departure and provision times, duration of stay, customs clearance, and release processes from terminals	As a maritime, port-neutral operator and specialist in port-to-door logistics, this company organises global supply chains in combined transport and bringing together the system strength of rail with the flexibility of trucking. As an important link between maritime ports and hinterland transportation, this stakeholder contributes significant industry experience to the analysis
IP 22	DLSP *Germany*	Neutral platform connecting intermodal actors and providing transport chain transparency and intermodal booking options	As a highly innovative SME and neutral platform for intermodal players, this stakeholder makes a decisive contribution to the analysis.
IP 23	Carrier Freight Forwarder *Germany*	Providing rail transport services, including locomotives, and rolling stock, transportation of hazardous goods, customs Clearance, train path orders, local operations, personnel, equipment, and combined transport	As a subcompany of the largest combined transport operator in Europe for road and rail transport, this stakeholder specialises in the transport of high-quality rail products in combined transport between the Netherlands and Germany. This partner contributes to the gain of knowledge with its perspective of a railway undertaking company.

Annex II: Quantitative Online Survey

Key	Section	#	Topic	Question type	Questions	Options (if applicable)	Optional	Dependencies
LOG_01	01_Logistics	1	**Role in multimodal transportation**	Multiple Choice	What roles does your organisation play in the transportation process?	1. Shipper 2. Carrier 3. Freight Forwarder 4. Multimodal Transport Operator (MTO) 5. Logistics Service Provider 6. Digital Logistics Service Provider 7. Support service provider or consultant 8. Software provider 9. Terminal operator 10. Infrastructure operator and/or manager		

						11. Governmental entity 12. Other...		
LOG_02	01_Logistics	2	**Relevant transport modes**	Multiple Choice	Please select all modes of transport (co-)operated with/by or relevant to your organisation?	1. Road 2. Rail 3. Inland waterways 4. Maritime (both deep sea and short sea) 5. Air 6. None		
LOG_03	01_Logistics	3	**# of transport modes per order**	Single Choice	On average, how many different modes of transport does your organisation use per shipment?	1. None 2. 1 3. 2 4. 3 or more 5. I don't know/not relevant for our organisation		
LOG_04	01_Logistics	4	**Impact of multimodality on efficiency**	Likert	Do you think using more than one mode per shipment helps to improve efficiency?	1. Not at all 2. Slightly 3. Moderately 4. Very 5. Extremely 6. I don't know		
LOG_05	01_Logistics	5	**Stages of the transport process**	Multiple Choice	What stages of the transport process do your organisation's activities cover, serve or address?	1. Pre-haulage 2. Main-run 3. Post-haulage 4. None		
LOG_06	01_Logistics	6	**Transport range**	Multiple Choice	What transport distances are relevant to your organisation?	1. < 15 km, commonly referred to as "last mile" 2. 15 km - 300 km 3. 300 km - 600 km 4. 600 km - 900 km 5. > 900 km 6. None		
LOG_07	01_Logistics	7	**Preference for relay traffic**	Single Choice	In the case of multimodal transportation, would you prefer many short distance segments or few long-distance segments?	1. Many short distance segments (less than 300 km) 2. Few long-distance segments (more than 300 km) 3. I don't know		
TEN_01	02_TEN-T	1	**Relevance of TEN-T corridors**	Single Choice	Is the concept of the Trans-European Transport Network, also known as TEN-T corridors, relevant to your organisation?	1. Yes 2. No 3. I am not familiar with the concept of TEN-T corridors		
TEN_02	02_TEN-T	2	**Introduction to TEN-T**					TEN_01_03 required
COR_01	03_Corridor	1	**Activities in North-Sea Baltic**	Single Choice	Is your organisation active in the North Sea-Baltic TEN-T corridor?	1. Yes 2. No 3. No, but there are plans to expand into the corridor 4. I don't know		
COR_02	03_Corridor	2	**Actors in North-Sea Baltic**	Text	What are the relevant carriers operating in the North Sea-Baltic TEN-T corridor?			
COR_03	03_Corridor	3	**Actors in North-Sea Baltic**	Text	What are the relevant Logistics Service Providers (LSP) operating in the North Sea-Baltic TEN-T corridor?			
COR_04	03_Corridor	4	**Actors in North-Sea Baltic**	Text	What are the relevant terminals and/or companies operating the terminals in the North Sea-Baltic TEN-T corridor?			
COR_05	03_Corridor	5	**Actors in North-Sea Baltic**	Text	What are the relevant infrastructure managing or operating entities operating in the North Sea-Baltic TEN-T corridor?			
COR_06	03_Corridor	6	**Actors in North-Sea Baltic**	Text	What are the relevant governmental agencies operating in the North Sea-Baltic TEN-T corridor?			
COR_07	03_Corridor	7	**Activities in Rhine-Danube**	Single Choice	Is your organisation active in the Rhine-Danube TEN-T corridor?	1. Yes 2. No 3. No, but there are plans to expand into the corridor 4. I don't know		
COR_08	03_Corridor	8		Text	What are the relevant carriers operating in the Rhine-Danube TEN-T corridor?			
COR_09	03_Corridor	9		Text	What are the relevant Logistics Service Providers (LSP) operating in the Rhine-Danube TEN-T corridor?			
COR_10	03_Corridor	10		Text	What are the relevant terminals and/or companies operating the terminals in the Rhine-			

					Danube TEN-T corridor?			
COR_11	03_Corridor	11		Text	What are the relevant infrastructure managing or operating entities operating in the Rhine-Danube TEN-T corridor?			
COR_12	03_Corridor	12		Text	What are the relevant governmental agencies operating in the Rhine-Danube TEN-T corridor?			
TEN_03	02_TEN-T	3	**Activities in TEN-T corridors**	Multiple Choice	In which TEN-T corridors does your organisation operate?	a. Yes b. No c. No, but expansion plans d. Don't know 1. Baltic-Adriatic Corridor 2. North Sea-Baltic Corridor 3. Mediterranean Corridor 4. Orient/East-Med Corridor 5. Scandinavian-Mediterranean Corridor 6. Rhine-Alpine Corridor 7. Atlantic Corridor 8. North Sea-Mediterranean Corridor 9. Rhine-Danube Corridor 10. None		
BM_01	04_Business Model	1	**Key activities**	Multiple Choice	What are your organisation's key activities?	1. Transportation management: managing and executing the physical transportation of goods across various transport modes 2. Logistics coordination: organising and managing all aspects of the shipping process, including route selection and carrier contracting 3. Scheduling and coordination: managing schedules for shipments to maximise throughput and minimise downtime 4. Loading and transshipment: executing the loading, unloading, and transfer of cargo 5. Shunting: moving and organising railway cars to assemble or disassemble trains 6. Commissioning: preparing and verifying systems, equipment, or facilities for operational use, ensuring they meet specified requirements and are ready for service 7. Customs and compliance: handling documentation and ensuring compliance with international trade regulations 8. Safety and security management: implementing and monitoring security protocols and safety practices within facilities 9. Maintenance and upkeep: conducting regular maintenance of infrastructure and equipment 10. Container handling: provision or repair and maintenance of containers 11. Storage and warehousing: storing of goods in designated facilities to ensure their safekeeping, inventory management, and timely distribution 12. Traffic management: planning and controlling the flow of vehicles 13. Consulting and support: offering expert advice on digital transformation and operational optimisation 14. Technology development: creating digital solutions for logistics processes 15. Platform development: building and maintaining digital platforms for logistics processes 16. Data analytics services: analysing logistics data 17. Cybersecurity services: ensuring digital platforms and data exchanges are secure from cyber threats 18. Customer relationship management: developing and maintaining strong relationships with customers to ensure satisfaction and repeat business 19. Training and development: offering training services to upskill employees in transport and logistics firms		

						20. Stakeholder engagement: communicating and collaborating with all parties involved 21. Other...		
BM_02	04_Business Model	2	**Customer segments**	Multiple Choice	For whom does your organisation create value?	1. Shipper 2. Carrier 3. Freight Forwarder 4. Multimodal Transport Operator (MTO) 5. Logistics Service Provider 6. Digital Logistics Service Provider 7. Support service provider or consultant 8. Software provider 9. Terminal operator 10. Infrastructure operator and/or manager 11. Governmental entity 12. Other... 11. Other		
BM_03	04_Business Model	3	**Information exchange**	Multiple Choice	With which roles do you exchange information as you create value? What is the direction of information flow?	a. Yes, receive from b. Yes, send to c. Yes, receive from and send to d. No e. Don't know 1. Shipper 2. Carrier 3. Freight Forwarder 4. Multimodal Transport Operator (MTO) 5. Logistics Service Provider 6. Digital Logistics Service Provider 7. Support service provider or consultant 8. Software provider 9. Terminal operator 10. Infrastructure operator and/or manager 11. Governmental entity 12. Other...		
BM_04	04_Business Model	4	**Information exchange**	Likert	Which information streams does your organisation receive, pass on or both receive and pass on?	a. Receive b. Receive and pass on c. Pass on d. Neither e. Don't know 1. Regulatory and compliance requirements and documentation (customs, insurance) 2. Cargo requirements and documentation (cargo information, transport unit requirements, handling equipment, contact details, safety requirements) 3. Transport requirements and documentation (Transport order, booking confirmation, Shipment specifications [mode of transport, transshipments], schedules [origin and destination, ETD, ETA], Transshipment equipment) 4. Payment and billing information (billing instructions, Invoicing, handling and transshipment rates, freight rates, storage rates) 5. Track-and-Trace information (Position, Change notification, Condition report, transshipment tracking, shipment status) 6. Routing conditions (weather and traffic forecast, infrastructure status. Terminal status, Transshipment spot availability, Storage space availability, capacity constraints) 7. Sustainability indicators 8. Incident and exception reporting		
BM_05	04_Business Model	5	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Transport Management System (TMS)?	1. Yes 2. No 3. I don't know		
BM_06	04_Business Model	6	**Logistics-specific IT systems**	Single Choice	Which TMS system does your organisation use?	1. SAP 2. Oracle 3. Alpega 4. Transporeon 5. Impargo 6. In-house 7. Other (free text)		BM_05_01 required
BM_07	04_Business Model	7	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Warehouse Management System (WMS)?	1. Yes 2. No 3. I don't know		
BM_07	04_Business Model	7	**Logistics-specific IT systems**	Single Choice	Which WMS system does your organisation use?	1. SAP 2. Oracle 3. Körber 4. Manhattan Associates 5. Luminate 6. In-house 7. Other (free text)		BM_07_01 required

BM_08	04_Business Model	8	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Enterprise Resource Planning System (ERP)?	1. Yes 2. No 3. I don't know		
BM_08	04_Business Model	8	**Logistics-specific IT systems**	Single Choice	Which ERP system does your organisation use?	1. SAP 2. Oracle 3. Sage 4. NetSuite 5. Epicor 6. In-house 7. Other (free text)		BM_08_01 required
BM_09	04_Business Model	9	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Customer Relationship Management System (CRM)?	1. Yes 2. No 3. I don't know		
BM_09	04_Business Model	9	**Logistics-specific IT systems**	Single Choice	Which CRM system does your organisation use?	1. Salesforce 2. Monday sales 3. Nimble 4. HubSpot 5. Pipedrive 6. In-house 7. Other (free text)		BM_09_01 required
BM_10	04_Business Model	10	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Supply Chain Management System (SCM)?	1. Yes 2. No 3. I don't know		
BM_10	04_Business Model	10	**Logistics-specific IT systems**	Single Choice	Which SCM system does your organisation use?	1. SAP 2. Oracle 3. MS Dynamics 4. Plex 5. IFS 6. In-house 7. Other (free text)		BM_10_01 required
BM_11	04_Business Model	11	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Asset Tracking System?	1. Yes 2. No 3. I don't know		
BM_11	04_Business Model	11	**Logistics-specific IT systems**	Multiple Choice	Which asset tracking system does your organisation use?	1. RFID 2. GPS 3. Barcode 4. NFC 5. Other (free text)		BM_11_01 required
BM_12	04_Business Model	12	**Logistics-specific IT systems**	Single Choice	Does your organisation use a Terminal Operating System (TOS)?	1. Yes 2. No 3. I don't know		
BM_12	04_Business Model	12	**Logistics-specific IT systems**	Multiple Choice	Which TOS does your organisation use?	1. Navis 2. CyberLogitec 3. GullsEye 4. Autostore TOS 5. ContPark 6. Interman (B. Rekencentra) 7. Inform 8. Berghof BLU 9. In-house 10. Other (free text)		BM_12_01 required
BM_13	04_Business Model	13	**Data exchange formats**	Multiple Choice	What formats does your organisation use to exchange data?	1. Standardised electronic data exchange formats (EDI/EDIFACT) 2. Office formats (.xls(x), .doc(x), .ppt(x)) 3. Comma-separated values (.csv) 4. .xml 5. .txt 6. PDF 7. E-Mail 8. Telefax 9. Paper 10. Other (free text)		
BM_13	04_Business Model	13	**Revenue streams**	Multiple Choice	Who is the primary entity responsible for financing or paying for the value or service provided by your organisation?	1. The customer itself 2. The state or government 3. No one 4. Another role		
BM_14	04_Business Model	14	**Revenue Streams/Business Models**	Multiple Choice	What describes your organisation's business model best?	1. Direct Sales Model: Products or services are sold directly to consumers without intermediaries 2. Subscription Model: Customers pay a recurring fee (monthly, yearly, etc.) to access a product or service 3. Marketplace Model: The company takes a commission or fee on transactions made between buyers and sellers on the platform 4. Freemium Model: Basic services are offered for free, while premium features, advanced functionalities, or additional content are available for a fee 5. Advertising Model: Revenue is generated through advertisements placed on the company's platform, paid for by advertisers who want to reach the platform's audience 6. Other...		
PLA_01	05_Platforms	1	**Potential of a digital platform on multimodality efficiency**	Likert	Do you think a digital platform could help orchestrate multimodal	1. Not at all 2. Slightly 3. Moderately 4. Very		

					transportation more efficiently?	5. Extremely 6. I don't know		
PLA_02	05_Platforms	2	**Utilisation of digital platforms**	Single Choice	Does your organisation already use a digital platform for collaboration with its partners and customers?	1. Yes 2. No		
PLA_03	05_Platforms	3	**Platforms in use**	Multiple Choice	Which digital platform does your organisation use for collaboration with partners and customers?	1. Transporeon 2. Sennder 3. Cesar-Next 4. Insta-Freight 5. Forto 6. Shippeo 7. FreightHub 8. Quicargo 9. Other (Free text)		PLA_02_02 required
PLA_04	05_Platforms	4	**Integrated solution**	Single Choice	Would you prefer a digital platform that is integrated into your existing digital infrastructure or an independent stand-alone solution that works via interfaces with existing IT services?	1. Integrated system 2. Standalone solution 3. No preference		
PLA_05	05_Platforms	5	**Information streams via digital platforms**	Likert	How important is the processing of information streams via a digital platform?	a. Must b. Should c. May d. Should not e. Must not f. No preference 1. Regulatory and compliance requirements and documentation (customs, insurance) 2. Cargo requirements and documentation (cargo information, transport unit requirements, handling equipment, contact details, safety requirements) 3. Transport requirements and documentation (Transport order, booking confirmation, Shipment specifications [mode of transport, transshipments], schedules [origin and destination, ETD, ETA], Transshipment equipment) 4. Payment and billing information (billing instructions, Invoicing, handling and transshipment rates, freight rates, storage rates) 5. Track-and-Trace information (Position, Change notification, Condition report, transshipment tracking, shipment status) 6. Routing conditions (weather and traffic forecast, infrastructure status. Terminal status, Transshipment spot availability, Storage space availability, capacity constraints) 7. Sustainability indicators 8. Incident and exception reporting		
PLA_06	05_Platforms	6	**Concerns regarding information exchange**	Multiple choice	Which concerns do you have when exchanging information via a digital platform?	1. Data security 2. Data privacy 3. Data integrity/Authentication 4. (Regulatory) Compliance 5. Technical issues 6. Interoperability 7. Standardisation 8. Other (free text)		
NEE_01	06_Needs	1	**Needs**	Ranking	Please rank the following needs according to their importance to your organisation from highest to lowest:	1. Data standardisation and automation 2. Integrated digital solutions 3. Facilitated data exchange and collaboration 4. Streamlined transport regulations 5. Advanced analytics and forecasting tools		
NEE_02	06_Needs	2	**Needs**	Single Choice	Do you can think of additional needs that need to be addressed when designing a digital platform?	1. No 2. Other (free text)		
GEN_01	07_General	1	**Gender**	Single Choice	Which gender do you identify with?	1. male 2. female 3. non-binary	x	
GEN_02	07_General	2	**Job Level**	Text	What is your current job level in your organisation?	Free text	x	
GEN_03	07_General	3	**Number of employees**	Single Choice	How many employees does your organisation have?	1. up to 9 2. 10 to 49 3. 50 to 249 4. from 250	x	
GEN_04	07_General	4	**Annual revenue**	Single Choice	How much is your estimated annual revenue in euros (€)?	1. up to € 2 million 2. up to € 10 million 3. up to € 50 million 4. more than € 50 million	x	
GEN_05	07_General	5	**Participation**	Single Choice	Are you interested in contributing to our	1. Yes 2. No		

					project by participating in an expert interview or stakeholder workshop?			
GEN_06	07_General	6	**Participation**	Text	Please enter your contact email address	Free text		GEN_05_01 required