SARIL

Sustainability And Resilience for Infrastructure and Logistics networks

D 1.4 Co-creation of requirements and strategies for resilience and sustainability dealing with disruptions

Deliverable Number	D1.4
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Due/delivered Date	30.11.2025
Reviewed by	Jan Tore Pedersen, Kris Schroven, Ana Maia, Benjamin Lickert
Dissemination Level	PU
Version of template	1.2

Start Date Project: 2023-06-01 Duration: 36 months Project ID: 101103978

This project has received funding from the Horizon Europe program of the European Union under grant agreement ID 101103978.

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Document revisions

Revision	Date	Comment	Author
1	19.09.2025	Draft	All content contributors
2	24.10.2025	Draft for review	All content contributors
3	10.11.2025	Revised document based on reviewers' comments.	Gunnhild B. A. Svaboe, Kelly Pitera
4	26.11.2025	Final Version after SO and QO check	Gunnhild B. A. Svaboe, Kelly Pitera

Executive summary

Developing solutions, tools and knowledge to manage and mitigate disruptions is essential for building resilient infrastructure and logistics networks. To ensure relevance and usability, these innovations must be co-created with logistics actors and stakeholders. The SARIL project brings together a diverse group of stakeholders from private and public sectors, spanning a wide geographical area. Many of them face similar overarching challenges related to disruption management; however, their specific needs vary. For example, a port operator, a logistics service provider and a transport ministry representative may all work with disruptions but at different levels and scopes, resulting in distinct requirements for tools, data and knowledge.

Deliverable D.1.4, based on findings from Task 1.4., summarizes the main insights from several co-creation workshops, covering topics such as challenges, requirements and needs, strategies for managing disruptions, the relationship between sustainability and resilience, data availability and sharing, the usefulness of tools to mitigate disruptions, and future disruptive events. The aim of the co-creation workshops was to create concepts for better solutions to deal with disruptions and to give further input to the ongoing work across the SARIL project, especially for tool development in WP3. Relevant stakeholders were invited to give input on their needs in dealing with disruptions and on how these align with the SARIL vision given certain conditions and questions.

The SARIL workshops revealed several cross-cutting needs and challenges related to disruption management in freight transport. The most prominent issue was the need for effective data collection and sharing among stakeholders, which also presents a major challenge due to the increased risk of cyberattacks as data exchange increases. Another key point is the importance of being proactive in disruption management, thus preparing before events occur, especially in relation to sustainability. However, environmental sustainability is not a primary concern for many stakeholders during crises. Lastly, the workshops highlighted the complexity of stakeholders' roles and the importance of increased collaborations across sectors and levels. A joint platform was widely supported as a vision to integrate existing solutions, supporting both operational and strategic decision-making, and aggregate diverse data sources, including unstructured data such as social media, to manage disruptions like social unrest and weather-related delays. However, competition, confidentiality, and regulatory constraints hinder data sharing, and stakeholders suggested that public ownership and incentives could help overcome these barriers. Discussions revealed a clear difference between operational and strategic levels in terms of data needs, tool usefulness, and capacity for environmental investments.

These findings align with established challenges in logistics and disruption management, and the Discussion (chapter 5) examines how technical solutions can be developed to address such challenges and what systemic changes are necessary to overcome them. By applying foresight methods and engaging stakeholders, the SARIL project provides valuable input for shaping future solutions and guiding tool development. Achieving sustainable operations across all levels requires coordinated action, with systemic change at the strategic level supported by international and national regulations that incentivize environmentally responsible practices in both daily operations and disruption management.

While the work of WP3 was done in parallel to Task 1.4 and already closed, this report will enter the work of Task 5.1 (that considers recommendations to be derived from the project work) as well as the work of Task 5.2 (that considers business models).

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List of Acronyms

Acronym	Definition
SARIL	Sustainability And Resilience for Infrastructure and Logistics networks
TEN-T	Trans-European Transport Network
NGO	Non-governmental organization
SHM	Structural Health Monitoring
SME	Small and medium-sized enterprise
DII	Disruption Information Interface

1 Introduction

This deliverable aims to provide knowledge that enable the development of solutions that are well equipped to manage disruptions in infrastructure and logistics networks. More specifically, it presents the results of co-creation workshops conducted within the SARIL project as part of task T1.4, designed to identify key requirements and strategies for building resilience and sustainability in response to increased disruptions in transport networks. “Co-creation” in this context refers to identifying, discussing and solving problems jointly between different types of participants and stakeholders within a specific field. In the SARIL project this is related to disruptions and disruption management in infrastructure and logistics networks. Disruptions to logistics networks and transportation systems, ranging from extreme weather and natural hazards to cyber-attacks and geopolitical instability, are increasing due to climate change and global uncertainty. These events can significantly affect the supply chain and negatively impact society as a whole if critical goods, such as medicines and food, are delayed (Barman et al., 2021). Therefore, stakeholders in logistics networks and transport infrastructure should strengthen their resilience to such events, ideally by managing and planning for disruptions in an environmentally sustainable manner. This deliverable contributes with knowledge on how stakeholders can develop such “green resilience”.

Stakeholders adapt differently and sometimes inadequately because they are not considering cascading effects in the supply chain (t’Serstevens & Major, 2025). Given the diverse range of public and private stakeholders across sectors and countries, stakeholder inclusion is essential for developing a holistic approach to green resilience. Thus, workshops covering key SARIL topics have been conducted to increase acceptance, improve stakeholder involvement in the scenario planning process, and secure impact for producing positive societal outcome of results. SARIL stakeholders are diverse, including logistic service providers, transport infrastructure operators, shippers and transport authorities at local, regional, and national levels. Involving and engaging this broad range of actors is essential to address the social, technological, regulatory and political concerns and uncertainties that affect sustainability and resilience of freight transport.

The workshops (digital and physical) included participatory foresight exercises to identify strategies for future solutions in dealing with disruptions. The exercises were developed based on findings from previous SARIL activities on scenario development (SARIL Project, 2023, 2024c) and input from stakeholders (SARIL Project, 2024a). The goal of the foresight exercises was to gain consensus but also identify dissensus on sustainability and resilience topics related to the SARIL’s vision, identify main disruptive events, as well as identify potential solutions and strategies to be further developed in other project WPs and activities.

Three scenarios were considered in the project and were the basis for the so-called Future Images workshops: Regional - Mantua in Italy, National - Iberian Peninsula and Global - Europe.

In the Regional Scenario, localized disruptions are examined, focusing on flood events and the cascading impacts of simultaneous cyber-attacks that compromise the flow and reliability of critical information needed for effective emergency response. The case study is set in the Province of Mantua, located in Italy’s Lombardy region. Goods movement in the province relies heavily on road transport, with bridges serving as critical nodes whose operational status is essential to the functioning of the network. Floods can inflict severe damage on bridge structures, such as pier scouring, jeopardizing their safety and usability. Given Mantua's strategic position along the Mediterranean, Scandinavian–Mediterranean, and Baltic–Adriatic TEN-T corridors, such disruptions would not only affect the local population and infrastructure but could also ripple across key European freight and transportation routes (SARIL Project, 2023). The SARIL tools *Scour Monitoring for Decision Support Tool* and the

Vulnerability and Traffic Tool jointly support responses to these challenges. The former estimates scour on bridge foundations and extrapolates these estimates to a network of bridges using Bayesian networks, while the latter assesses the resilience of traffic networks considering disruptive events and reduced capacities. More can be found about the tools in chapter 2.2.1.

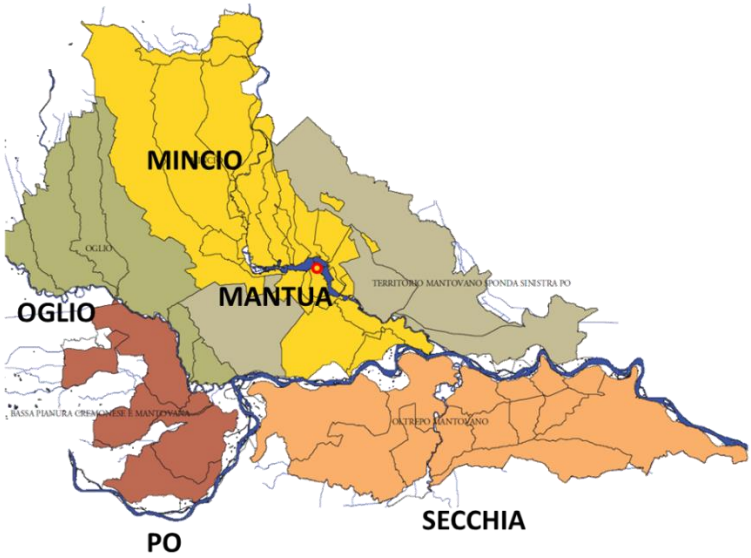

Figure 1.1: Regional scenario description.

The National Scenario examines the impact of extreme wildfires on the main logistics infrastructures of the Atlantic corridor in the northwest of the Iberian Peninsula, between Spain and Portugal. These infrastructures include ports such as Vigo, Leixões and Aveiro; the PLISAN logistics platform; Maia Airport; railway lines such as the Minho line and line 810 (Vigo–Ourense); and motorways such as the A3 in Portugal and the A55 in Spain (SARIL Project, 2023). Climate change has increased the frequency and severity of forest fires in the region, due to extreme heatwaves, dry vegetation, abandonment of rural activities, and poor forest management. The proximity of these fire outbreaks to transport routes poses a direct threat to the freight network, with significant consequences for both national and European logistics. The SARIL tools *Traffic Simulations* and *Natural Hazard Maps* are used to evaluate the impact of disruptions due to forest fires on mobility (SARIL Project, 2024b). More can be found about these tools in chapter 2.2.1.

Figure 1.2: National scenario description.

The Global-European scenario concerns large-scale disruptions in freight transport networks caused by global crises, such as pandemics, geopolitical conflicts (e.g., the war in Ukraine), or structural disruptions affecting Asia-Europe trade routes. These disruptions are analysed using simulations integrated with data flows and real-time disruption information, enabling dynamic monitoring of the situation and adaptive management of the logistics network. In this context, the scenario focuses, among other things, on critical connections, such as the maritime route through the Suez Canal and the New Silk Road rail corridors, taking into account the domino effect resulting from blockades, e.g. strikes in key European ports or the closure of rail terminals due to armed conflict or economic sanctions (SARIL Project, 2023). In this scenario, the *ASTROIT transport simulation tool* and the *Disruption Information Interface (DII)* are used in conjunction with *Route attributes tool* including energy and emissions modules to assess the system's response and resilience. More information about the functionality of these tools can be found in chapter 2.2.1.

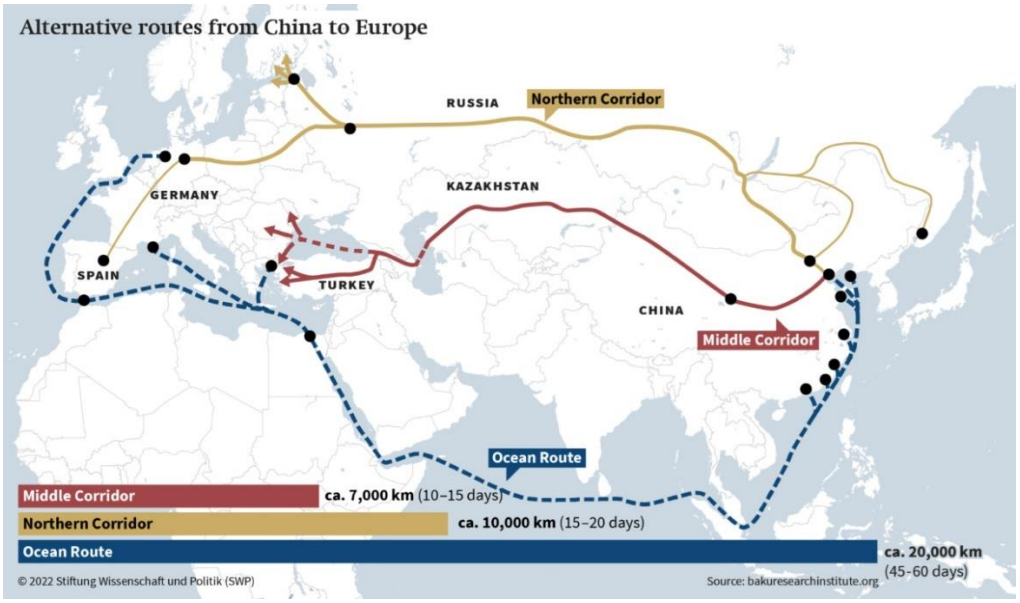

Figure 1.3: EU/Global scenario description.

Two series of workshops, **Future Images** and **Pathways**, were developed and conducted as part of Task 1.4. The first set of workshops were geographically linked to the three scenarios (Regional – Mantua region of Italy, National – Spain and Portugal, European – largely Poland and Germany), while the second set focused on Pan-European themes, thus expanding the geographic scope. This is further described in chapter 2.

The remainder of this deliverable will outline the methodologies used in developing the workshops and present the results from the two series of workshops, before discussing the results and their applicability.

2 Methods: Participatory Foresight for Co-Created Pathways Towards Resilience

This chapter describes the scientific methods used to co-create concepts and ideas for solutions that are more equipped to manage disruptions in transport infrastructure and logistics networks. At the core of these methods is participatory foresight, in which diverse stakeholders are actively involved in envisioning and shaping possible futures to inform decision-making (see e.g. Nikolova (2013)). Vision-building foresight techniques are especially relevant for SARIL, as they facilitate the exploration and articulation of potential future disruptions while encouraging creative, out-of-the-box thinking. These methods function as "thinking tools," enabling stakeholders to reflect collectively, discuss perspectives, and develop innovative ideas and strategies that may not have emerged otherwise (de Brabandere & Iny, 2010). Using vision building along with backcasting techniques, we engage the stakeholders within several discussion topics considering medium- and long-term perspective (inspired by, among others, Bjørkhaug (2020) and Drew (2006)). The overarching topics covered concern how organisations deal with disruptions, and what specific handling approaches, challenges, data, sustainability and policies are needed. Furthermore, since a crucial part of the project is to integrate sustainability into the resilience solutions of logistics actors, transformation in the personal sphere, including beliefs, values and worldviews need to be considered. Although climate change requires rapid and deep alteration of attitudes, norms, incentives and values, many companies within the logistics sector continue to prioritize speed of delivery and cost-efficiency, assuming that prior experience sufficiently prepares them for future challenges (t'Serstevens & Major, 2025). Thus, approaches and insights from sustainability transitions research (Geels et al., 2023) highlighting the need for deeper socio-technical transitions (Kanger & Schot, 2019) that are co-created with relevant actors (Bjerkan et al., 2021; Loorbach et al., 2017) will be needed to develop resilience strategies that align operational efficiency with long-term sustainability goals.

As future-oriented technology analyses are encouraged to adopt mixed methods and methods triangulation (Kaivo-oja, 2017), this deliverable builds upon previous work within SARIL, collectively employing on a combination of qualitative and quantitative interviews, as well as co-creation methods (see Solbu et al. (2023) for an useful overview). The integration between qualitative and quantitative methods has also been described in deliverable D1.3 of the SARIL project (SARIL Project, 2024a). Figure 2.1. illustrates the methodological components of the participatory foresight activities that contribute to this deliverable.

This deliverable of the SARIL project focuses on the second phase of the participatory foresight process, implementing co-creation workshops. As indicated in Figure 2.1., elements of the first phase of this process (occurring in Task 1.3 and reported in deliverable D1.3 (SARIL Project, 2024a)) served as inputs to inform the development of both series of workshops within Phase 2. Further, findings from the Future Images workshops inform the Pathways workshops. This is further described in section 2.1 and 2.2.

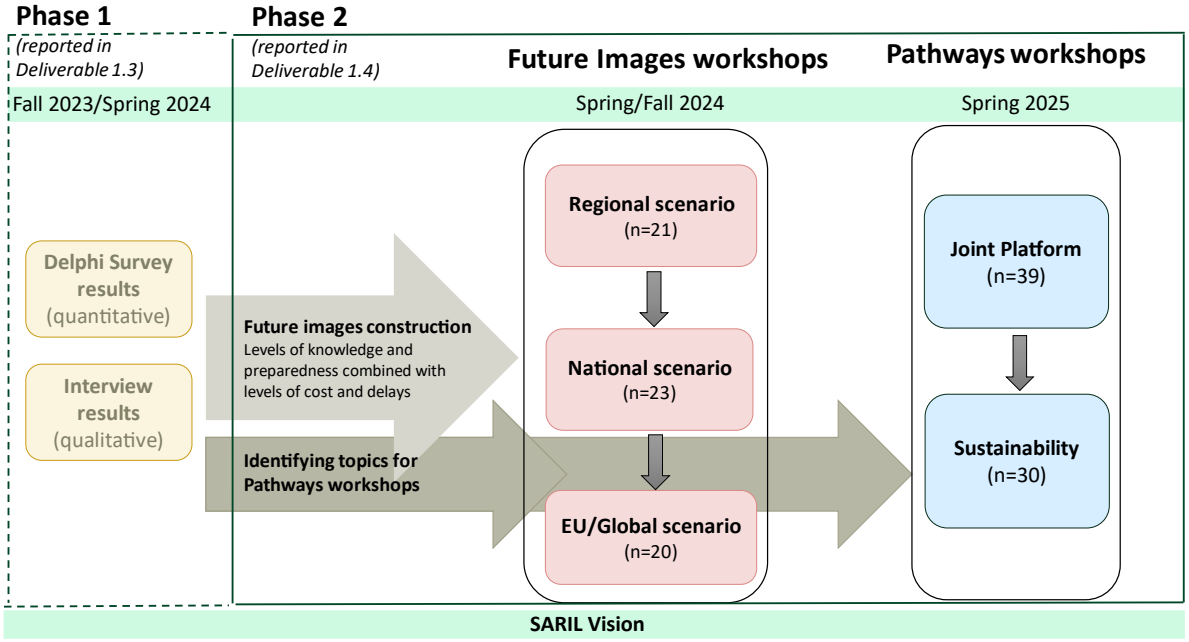

Figure 2.1 Summary of methodological process[1].

The overarching approach guiding the research presented in this deliverable is rooted in the SARIL project's vision which was developed in collaboration with all project partners and based on input from Task 1.2. *Sustainability and resilience evaluation of strategic logistics network* (SARIL Project, 2024c). The vision is:

> *Improving decision-making in transport and logistics systems in the face of disruptions by combining resilience and sustainability, where a system is resilient and sustainable if it uses minimal resources to withstand and recover from disruptions.*

The first workshop series, named Future Images, was geographically linked to the three project areas and associated scenarios (Regional – Mantua region of Italy, National – Spain and Portugal, European – largely Poland and Germany). The Future Images workshops used backcasting as a method to examine different versions of "future images," which were developed based on identified consequences and barriers within disruption management. The knowledge gained from the regional workshop was effectively communicated to the national workshop, and subsequently, from the national workshop to the global workshop, as demonstrated in Figure 2.1. The second workshop series, named Pathways, shifted the focus from the geographic dimensions to thematic ones, addressing specific topics that emerged from the first series of workshops, such as the viability of a joint platform and sustainability in relation to disruption response. This allowed for a deeper exploration of the project's main goal and vision around combining resilience and sustainability for improving decision-making in transport and logistics systems in the face of disruptions.

[1] Delphi survey and qualitative interview findings are documented in previous SARIL dissemination activities (SARIL Project, 2024a; Svaboe et al., 2024)

2.1 Future Images Workshops

As seen in Figure 2.1, three Future Images workshops were conducted during 2024, on national, regional and global levels. In total 64 different stakeholders participated on these workshops (see appendix for details).

Table 2.1 Stakeholders in Future Images workshops.

Scenario workshop	Stakeholder type
Regional (n=21)	Infrastructure owner or operator (n=4) Logistics and transport management/operation companies (n=1) Associations/Representative organisations/NGO (n=1) Public authorities (others) (n=7) Researchers/Consultants (n=8)
National (n=23)	Infrastructure owner or operator (n=4) Logistics and transport management/operation companies[2] (n=9) Associations/Representative organisations/NGO (n=3) Technology solution company (n=1) Researchers/Consultants (n=6)
European (n=20)	Infrastructure owner or operator (n=4) Logistics and transport management/operation companies (n=8) Associations/Representative organisations/NGO (n=1) Researchers/Consultants (n=6)

To create a common framework that is compatible across the three Future Images workshops of the project, we developed a step-by-step approach for the scenario workshop series that allowed customizing for each scenario/geographic area. Each workshop had a group discussion set within different "future images" in each of the workshop areas (regional, national and Global/European perspectives). Stemming from participatory foresight methodology (De Smedt et al., 2013), future images were used to orient discussions towards new ideas and solutions.

The following steps were followed for the Future Images workshops for all scenarios:

1. Presentation of project vision and goal, and short vision discussion
2. Presentation of the focus area/scenario (system boundary) by scenario leader and host, building particularly on Task 1.1. ((SARIL Project, 2023)
3. Presentation of previous survey findings on experience with disruptions and what consequences they have, handling strategies applied, and barriers to applying these. The presentation was based findings from Task 1.3. (*Identification of challenges, requirements, and future expectations through participatory foresight of stakeholders*) (SARIL Project, 2024a; Svaboe et al., 2024). These were also the basis for the future images, described further below.
4. Explore the future images within groups through a “world café”-approach in which all groups visit each future image table and work through predefined questions.
5. Within each future image discussion, the participants were instructed to keep the SARIL vision in mind while answering questions related to how they manage disruptions given the specific scenario system boundary. There were questions both on how they manage disruptions currently, and how they wish for disruptions to be managed in the future. The

[2] One stakeholder was also an end user of transport. See appendix for details.

questions covered general mitigation measures, tools used today and tools that should be used, and challenges when managing and mitigating disruptions. See Appendix A.2. for question descriptions.

2.1.1 Construction and Use of Future Images

To build the future images, we relied on data from a Delphi survey (Phase 1 in Figure 2.1) (SARIL Project, 2024a) among infrastructure owners and operators, logistics and transport companies, goods owner and producers, digital and technological service providers, as well as authorities representing diverse sectors. The survey was conducted in collaboration with SARIL's sister project ReMuNet[3]. As elaborated in deliverable D1.3. (SARIL Project, 2024a) and in Svaboe et al. (2024), respondents reported on disruptions that have impacted them the last five years, the severity of the disruptions' consequences, availability of response options and barriers towards employing needed response options (see Appendix A.1. for Delphi survey question descriptions).

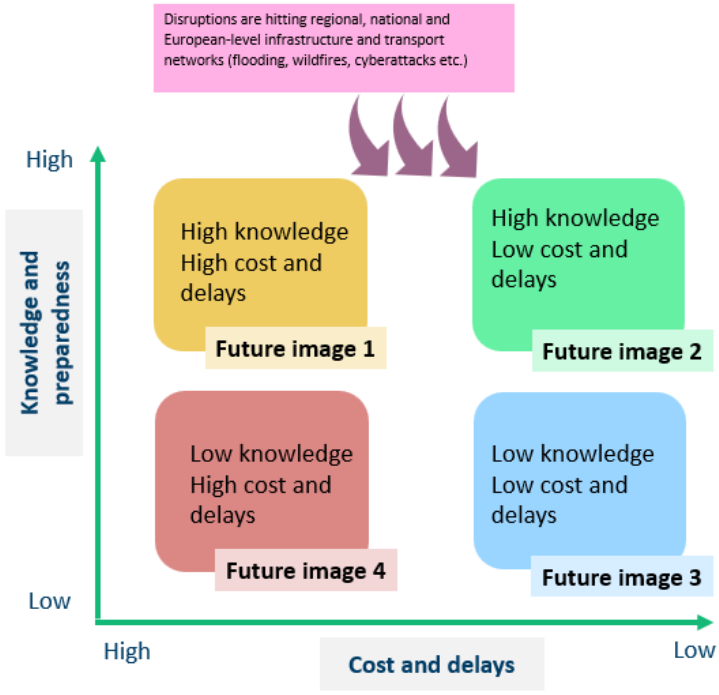

Figure 2.2: Future images description.

Results from the Delphi study were used to construct Future Images, highlighting (1) the level of knowledge and preparedness (resources) among respondents, and (2) the level of costs and delays (consequences) associated with disruption management. In the survey, knowledge was considered a key factor to influence future disruption management and levels of preparedness within the transport system. The respondents considered the level and sharing of knowledge, whether about potential disruptions, available solutions, or market conditions, to be decisive in shaping preparedness and adaptive capacity within the transport system. Furthermore, respondents considered delays and costs to be mutually reinforcing, direct effects of disruptions, as delays frequently lead to higher operational costs, supply chain disruptions, and inflationary pressures that make recovery and adaptation more challenging. Moreover, rising costs not only result from disruptions but can also hinder the adoption

[3] https://remunet-project.eu/

of new mitigation measures or technologies, reinforcing a cycle of vulnerability within the transport system.

As seen in Figure 2.2, Future Images were developed from a matrix of low/high levels of resources and consequences. Future Image 4 depicts a baseline, business as usual image, in which the future is similar to the current status quo, where stakeholders are low in resources (knowledge and preparedness) and experiences high consequences (costs and delays) from disruptions. Conversely, Future Image 2 describes an ideal future in which stakeholders are high in resources to meet and be prepared for disruptions, and where the consequences of disruption are low. Although the prominence of the different Future Images varied between workshops[4], they collectively provided useful input about preconditions for moving towards Future Image 2.

2.2 Pathways Workshops

The Pathways workshops consist of two workshops that collectively addressed the regional, national and European levels. The goal of the workshops was to work towards describing what it would take to reach a desired common future. The Common Futures can be understood as a type of vision that aligns with the SARIL vision presented in section 2.1. The Common Futures were developed and reviewed by SARIL project members prior to the workshops. The construction of Common Futures for each scenario level was based on results from the first round of workshops. In the workshops, the stakeholders explored how to achieve the Common Futures through targeted pathways questions.

SARIL partners were invited to present tools developed within the project to relevant stakeholders (see Table 2.2. for tool demonstration list and section 2.2.1 for a brief description of the demonstrated tools). The first workshop was focused on how one could reach **the ambitious vision of creating a Joint Platform** for providing information and solutions in response to disruptions. A wide range of stakeholders within freight transport participated in the workshop. Furthermore, the discussion centred around **what should be included in such a platform** as well as **barriers and drivers towards developing such a platform**. The second workshop had a focus on **sustainability** and addressed opportunities and challenges for including sustainability in preparation and response to disruptions to freight transport systems. Environmental sustainability can be challenging to prioritise when managing a disruptive event, due to the importance of continuity of service (as also highlighted in the finding of Task 1.3 (Svaboe et al., 2024)). This was also discussed in the first pathways workshop, encouraging a deeper dive into sustainability for this last workshop. Results are based on facilitator notes, documenting the discussions of the workshops.

Table 2.2 Pathways workshop tool demonstrations.

Pathways workshop	Tools demonstrations
Joint platform workshop	Scour monitoring for decision support (Polimi)
	Natural Hazard Map (UVigo)
	Disruption information interface (L-PIT)
Sustainability workshop	Scour monitoring for decision support (Polimi)
	Vulnerability and Traffic Tool (RINA)
	Energy module (SINTEF)

[4] Regional workshop included all Future Images. National workshops included Future Image 1 and 2. Global workshop included images 1, 2 and 3.

	ASTROIT (Fraunhofer EMI)

Table 2.3 provides an overview of the stakeholder types represented in the digital Pathways workshops. The high proportion of Researchers/Consultants can be attributed to the participation of multiple SARIL project members, given the workshops' emphasis on tools. For detailed information on stakeholder involvement in each workshop, please refer to Appendix A.4.

Table 2.3 Stakeholders in Pathways workshops.

Pathways workshop	**Stakeholder type**
Joint Platform (n=39)	Infrastructure owner or operator (n=5) Logistics and transport management/operation companies (n=10) End users of transport (n=1) Associations/Representative organisations/NGO (n=0) Public authorities (others) (n=1) Technology solution company (n=1) Researchers/Consultants (n=21)
Sustainability (n=30)	Infrastructure owner or operator (n=2) Logistics and transport management/operation companies (n=8) End users of transport (n=0) Associations/Representative organisations/NGO (n=3) Public authorities (others) (n=0) Technology solution company (n=2) Researchers/Consultants (n=15)

2.2.1 Tool Descriptions

The development of the SARIL Toolkit took place in parallel with the project's co-creation activities. As mentioned, several of the tools were presented within the workshops. These tools are summarized below and further information about their development and simulation activities can be found in SARIL deliverable 3.1. (SARIL Project, 2024b) and 3.3 (SARIL Project, 2025a). A brief summary of the complete suite of tools developed within the project can also be found in SARIL deliverable 3.4 (SARIL Project, 2025b).

In the Regional Scenario, the **Scour Monitoring for Decision Support Tool,** developed by POLIMI, is a cutting-edge solution that empowers infrastructure managers with real-time, risk-based decision-making capabilities during flood events. This tool leverages data from Structural Health Monitoring (SHM) sensors, potentially installed on just a single bridge, to evaluate structural integrity across the entire network. It continuously updates the reliability status of each bridge and, during emergencies, provides the optimum management plan that determines whether a bridge should remain open or be closed to reduce risk. Integrated with a cybersecurity layer, it also ensures the integrity and reliability of monitoring data, protecting against disruptions from potential cyber threats. By avoiding overly conservative closures, common in current emergency protocols, this tool helps minimize unnecessary bridge shutdowns, preventing costly delays, reducing downtime, and cutting emissions caused by unnecessary detours. Its real-time damage-state indicators (on a 1-to-5 scale) enable logistics managers to reroute freight operations efficiently, lowering fuel consumption and promoting environmental sustainability while ensuring safety and continuity of operations.

Further in the Regional Scenario, the **Vulnerability and Traffic Tool**, developed by RINA, complements SHM approach by providing a broader, system-level analysis of how natural hazards impact

transportation networks. Designed to assess network functionality, this tool evaluates traffic flow, service levels, and the vulnerability of specific infrastructure components during disruptive events. It helps identify critical network links most at risk, prioritize mitigation actions, and assess the effectiveness of resilience strategies. A key strength of this tool is its ability to bridge the gap between asset-level risk assessments and network-wide consequences—something traditional engineering analyses often overlook. By quantifying the ripple effects of disruptions on traffic and service continuity, the Vulnerability and Traffic Tool helps decision-makers implement smarter, targeted interventions that reduce both economic losses and environmental impacts. Together with the Scour Monitoring tool, it supports a holistic and sustainable approach to infrastructure resilience, ensuring that both individual assets and the broader transportation system are managed effectively under pressure.

In the National Scenario, the **Natural Hazard Maps**, developed by UVIGO, is a tool that uses open-access sources to address infrastructure disruptions caused by forest fires and adverse weather events through prevention. This tool provides three products. The first is a Forest Fire Risk Map, which uses a scale from 1 (very low risk) to 5 (very high risk) and assesses fire risk in the vicinity of infrastructure based on multiple factors (vegetation, climate, historical data, etc.). Second, forest fire spread maps are produced using the software “Flammap,”, indicating the Minimum Arrival Time of the fire to infrastructure. The third product consists of a series of hourly maps showing potential alerts for extreme weather events in a given region, such as heavy rainfall, snow, or strong winds.

To generate each of these maps, data sources such as satellite imagery, vegetation, topography, infrastructure, and meteorological conditions are essential. This tool is designed to support preventive decision-making in strategic planning. While it can also be useful for the general public (for example, in route planning) it is primarily intended for emergency services, public administrations, and infrastructure managers.

In the European scenario, three individual tools are integrated: the **Disruption Information Interface (DII), ASTROIT** and the **Energy Module.** These tools enable the real-time modelling of cargo flows, the identification of bottlenecks, and the testing of mitigation strategies, such as dynamic cargo redirection, the use of alternative corridors (e.g., the southern route via Istanbul), or switching to more sustainable modes of transport. The simulations are based on real operational data provided by logistics stakeholders (e.g., Gebrüder Weiss, CSL) and take into account the current geopolitical context, including the closure of the port of Hamburg or the need to avoid routes through Minsk and Kiev.

The **DII tool**, developed by L-PIT, serves as a central platform for collecting and sharing data on disruptions in real time. By aggregating data from multiple sources – tools developed as part of the SARIL project, publicly available external sources, and user-specific information sources, it enables immediate detection and reporting of disruptions in the transport network, such as port closures, border blockages or disruptions at intermodal terminals.

Based on data from the DII, the **ASTROIT tool**, developed by Fraunhofer, can simulate the impact of disruptions on European supply chains by analysing freight flows, the availability of alternative routes and the effectiveness of mitigation strategies (e.g. rerouting via another corridor, changing the mode of transport). This provides users with reliable operational scenarios for making strategic logistics decisions in crisis situations.

ASTROIT utilises inputs from the **Energy module**, developed by SINTEF, which provides energy and emissions indicators for each route and operational variant analysed. This allows users to compare

not only delivery times and costs, but also CO_2 emissions and energy consumption between the routing alternatives from ASTROIT. The integrated use of these three tools gives end users the ability to respond dynamically to disruptions across Europe, gain full insight into the operational and environmental impacts of logistics decisions, and plan resilient and sustainable logistics in line with the principles of synchro-modality.

The combined tools, DII, ASTROIT and the Energy Module, form an integrated decision support architecture that significantly increases the resilience and flexibility of European transport networks while maintaining environmental standards. The integrated decision-support architecture is of key value to tool end users including logistics and transport managers, logistics operators and infrastructure owners, because it enables them to anticipate disruptions, evaluate viable response strategies in real time, and select the most efficient and sustainable logistics solutions.

2.2.2 Mini-Survey

A short survey was conducted during the Joint Platform Pathways workshop (first digital workshop) to encourage active participation from the stakeholder participants. The purpose of the mini-survey was to link earlier SARIL findings on handling approaches (i.e., disruption management) for resilience, drawn from the Future Images workshops, stakeholder interviews and a previous survey to the presentations and discussions around the proposed "joint platform." The collection of disruption management measures was reviewed, summarized, and categorized for inclusion in the mini-survey. Participants were then asked: "*Which mitigation measures should be included in the joint platform?*" They could choose as many measures as they considered relevant. Table 2.4 lists the mitigation measures presented in the mini-survey. Note that only the individual mitigation measures were presented to the participants; the categories were used solely for the analysis of the results. As part of the Joint Platform Pathways workshop, 14 participants responded to the mini-survey.

Table 2.4 Mitigation measures presented in mini-survey.

Mitigation Measure	**Mitigation category**
Climate adaptation planning	Preventative planning
Emergency/contingency planning	Preventative planning
Data-driven decision support tools	Data and digitalization
Data interoperability and digital solutions integration	Data and digitalization
Transparent data sharing	Data and digitalization
Data collection	Data and digitalization
Emissions management	Modelling
Weather/climate forecasting	Modelling
Hazard identification	Modelling
Risk assessment	Modelling
Predictive modelling	Modelling
Maintenance	Operational management
New infrastructure construction	Operational management
Infrastructure capacity enhancement	Operational management
Supply chain (logistics) optimization	Operational management
Real-time traffic alerts	Tracking and Monitoring
Infrastructure and equipment monitoring	Tracking and Monitoring

Weather and environmental monitoring	Tracking and Monitoring
Vehicle and cargo tracking	Tracking and Monitoring
Emergency communication	Collaboration and Communication
Multi-stakeholder coordination and information sharing	Collaboration and Communication
Transition to alternative (green) energy sources	Alternative Transport and Route Adjustments
Rerouting	Alternative Transport and Route Adjustments
Intermodal solutions	Alternative Transport and Route Adjustments
Mode shifts	Alternative Transport and Route Adjustments

3 Future Images: Results and Analysis

The following chapter describes the main results from the three scenario workshops that applied the Future images approach. The goal was to ensure that participants considered the SARIL vision while answering questions related to how they deal with disruptions within the specific scenario system boundaries, both today and in the future; in other words, how disruptions are currently managed and how participants envision improved disruption management going forward. These questions concerned, among other things, general measures, tools currently in use and those proposed for future adoption, as well as existing and potential challenges in mitigating disruptions.

3.1 Regional Scenario

The Future Images workshop for the Regional Scenario, led by Politecnico di Milano (POLIMI) and the Interregional Agency for the Po River (AIPo), engaged stakeholders in an open dialogue on the different ways information availability and emergency management costs could influence resilience in regional transport systems. Through discussion tables and plenary exchanges, participants were asked to reflect on a set of four future scenarios and to align their responses with the SARIL vision.

Stakeholders were introduced to **Future Image 1**, a situation characterised by poor information and high emergency costs. Here, the lack of reliable and updated data was seen as a central problem, leading to the necessity of building more robust predictive models and weather forecasts. The absence of information would make coordination difficult and force authorities to rely on costly, reactive measures. Stakeholders pointed out that in such a scenario, extending the return periods of extreme events in assessments, promoting systematic training during peacetime, and improving collaboration among institutions would be fundamental. Concern was also raised that over-dependence on digital platforms could worsen vulnerabilities in case of cyberattacks, reinforcing the importance of maintaining traditional, non-digital action plans. In **Future Image 2**, where poor information is paired with low emergency costs, discussions emphasised the risks of complacency. Although the economic burden of disruptions might appear limited, the lack of data and situational awareness would expose the transport network to cascading risks, particularly during cyberattacks. Stakeholders stressed the need for early identification of critical nodes in the network, forward-looking assessments that integrate climate change considerations, and investments in risk management tools. Training, awareness campaigns for the population, and preparedness for unknown threats were all considered vital in this scenario. **Future Image 3** envisioned a more optimistic balance: available information combined with low emergency costs. In this case, participants highlighted the opportunities provided by advanced data models, interoperability across systems, and predictive tools. Artificial intelligence, digital twins, and adaptive models could allow more effective responses, even when disruptions occur. This future image discussion underlined the importance of green transition policies, sustainable transport solutions, and the integration of new technologies into existing infrastructures. At the same time, participants cautioned that strong investment in innovation must be matched by resilient communication networks and continuous maintenance, ensuring that short-term efficiencies do not undermine long-term resilience. Finally, **Future Image 4**, with available information but high emergency costs, prompted reflections on the paradox of knowledge without efficiency. Even with accurate datasets, forecasts, and predictive models, high costs could arise if planning and coordination are fragmented or if excessive bureaucracy slows down responses. Stakeholders pointed to the need for decentralised policies, streamlined decision-making, and the reduction of administrative burdens as ways to prevent inefficiencies. The debate also emphasised that while automation and digitalisation can increase efficiency, they may create vulnerabilities if over-relied upon. Resilient networks,

continuous monitoring of infrastructure, and clear task forces for intervention were considered vital countermeasures.

Across all four future images, several cross-cutting themes emerged. These included the critical importance of planning and coordination among authorities, the role of training and simulations during normal operations, the integration of climate change into long-term strategies, and the need to guarantee cybersecurity and reliable data management. Although measures such as greener vehicles (e.g. hydrogen and electric vehicles), automation and app development were brought up, stakeholders consistently highlighted that resilience in regional transport cannot be achieved through technology alone. Instead, it requires a balanced synergy of updated data, robust organizational strategies, effective tools, and human competence. The joint conclusion of the workshop was that resilience depends not only on access to information and technology but also on the quality of cooperation, governance, and the flexibility of the system. It is through this combination that regional transport networks in Italy will be able to withstand future disruptions caused by both natural and cyber-related events.

3.2 National Scenario

The Future Images workshop covering the National Scenario was held at the *Port Authority of Vigo*. Nineteen stakeholders from Portugal (24%) and Spain (76%) reflected on the leading solutions and challenges of two future images.

Regarding **Future Image 1**, which depicts a context of high knowledge with high delays and costs, stakeholders identified internal collaboration and cooperation between stakeholders as the most critical solution. This was followed by visibility of cargo information, which relates to the transparency in cargo characteristics and actors, where the visibility allows for implementing intermodal reactions. Additional solutions included the flexibility of the supply chain, which includes providing intermodal capacity as well as allowing for changes in the use of infrastructures. Based on these aspects, participants indicated that the system and its personnel must be enhanced by providing training for upskilling and multiskilling. Other solutions included automated negotiations and implementation of AI, but to a lesser extent.

The main challenges of **Future Image 1** included the lack of availability of specific training programmes for upskilling personnel, the current excessive bureaucracy that slows down logistic processes, and the risk of cyberattacks. Stakeholders emphasised that, although it was stated as the most critical solution, achieving information visibility and fostering collaboration between competitors remains a significant challenge to overcome. Participants specified that one of the main challenges during disruptive events involves defining and managing priorities.

For **Future Image 2**, which describes high knowledge and preparedness with fewer delays and lower costs, collaboration between stakeholders and agents involved in the logistics sector was again a determinant solution, followed by continuous training plans and system backups. Adapting to new technologies, such as robotics, machine learning, digitalisation and integration of AI, within individual companies and across the sector as a whole emerged as an important topic for consideration. Other solutions involved diversifying suppliers and changing to short-distance deliveries.

The main challenges were also related to cybersecurity and bureaucracy, as well as difficulties in adapting systems and people to new contexts. Other challenges included harmonising regulatory policies and data security processes not only in Europe but worldwide.

For comparison purposes, the solutions identified by stakeholders within **Future Image 1** and **Future Image 2** have been categorised based on common aspects, the logistic approach, and the data management strategy. These solutions have also been categorised based on whether they are related to preparedness or reactive actions. As illustrated in Figure 3.1, common aspects among **Future Images** include *Collaboration*, *Personnel training*, and *Digitalisation (AI, machine learning, etc.),* all considered within the preparedness phase. Regarding the logistic approach, **Future Image 1** contemplated a reactive action, such as using the *supply chain and infrastructure flexibility*. In contrast, actions within the **Future Image 2** were more related to preparing the system before disruptions by *Diversifying suppliers* and conducting *Short-distance transport* services. A similar behaviour was observed regarding data management as in **Future Image 1**; data visibility is sought during disruptions (reactive action) rather than ensuring that data is available through system backups (protective action), as suggested in **Future Image 2**.

It should be noted that both **Future Images** assume high knowledge and preparedness; however, in **Future Image 1**, there are more delays and higher costs compared to **Future Image 2**, which has fewer delays and fewer costs. Therefore, solutions regarding *Supply chain and infrastructure flexibility* (**Future Image 1**) try to minimise the economic impact by using existing infrastructure and by monitoring the performance through cargo visibility.

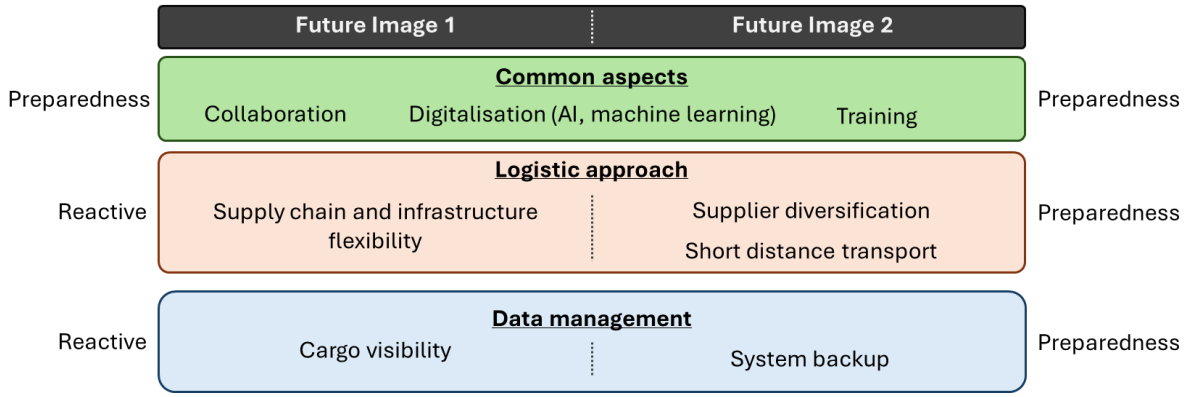

Figure 3.1: Comparison of solutions between Future Images – National Scenario.

Key findings from the workshop suggest that stakeholders see the ideal logistics network as one built on stronger communication and collaboration across all actors. A shared, easy-to-use app providing real-time updates on traffic, routes, weather, strikes, and other disruptions was seen as the most promising tool, though concerns remain about competitors' reluctance to share information and the risks around data protection. Continuous training, clearer protocols, and well-designed contingency plans—such as alternative routes, suppliers, or transport modes—were also considered essential, but many smaller operators struggle with the costs, regulatory barriers, and infrastructure limitations needed to make them viable.

Technology and innovation emerged as another cornerstone: full digitalization of data, widespread use of AI and robotics to improve safety and efficiency, and access to user-friendly systems would all significantly boost productivity. Yet, implementation is expensive, especially for SMEs, and raises new challenges around worker training, cyberattacks, and system failures. Sustainability was recognized as important, with a shared vision of moving towards low or zero emissions, though its adoption is still constrained by costs linked to equipment, training, and resource management. Finally, stakeholders called for less bureaucracy and smoother procedures in logistics operations, though they acknowledge that meaningful regulatory changes can only be driven by public authorities.

3.3 European Scenario

The Future Images workshop on the European scenario brought together representatives of logistics and transport management and operation companies, infrastructure operators, and end users of transport, as well as researchers. Discussions focused on three alternative visions of the future, differing in terms of the level of preparation, availability of knowledge and operational impacts in the form of costs and delays in European logistics networks.

In, **Future Image 1**, despite a high level of knowledge and preparation, participants focused on the parallel increase in costs and delays. The need for *complete transparency* in global data exchange, especially for information on container availability and shipping schedules, supported by political commitment, was identified as a crucial priority, since companies often lack sufficient incentives to share information voluntarily due to high operating costs. The significant role of *intelligent systems, based on both artificial and human intelligence*, which will enable the classification and processing of the huge amounts of data necessary for decision-making, was also emphasised. Another important aspect, particularly in the context of the rail sector, was the need for *increased regulatory flexibility* for train drivers and a more balanced distribution of freight flows across ports and logistics hubs in Europe, which would increase the resilience of the entire logistics network. The need to *implement public policies supporting investment* in environmentally sustainable solutions was also highlighted. The most serious challenges include the *lack of incentives to share data* and *information overload*, which can paradoxically hinder the decision-making process. A conclusion was that although standardisation of systems can reduce costs and simplify the functioning of logistics networks, simultaneous dependence on one or two technological solutions can lead to serious disruptions in the event of failure.

Future Image 2 assumed a high level of knowledge and preparation, but with lower costs and fewer delays. In this scenario, participants envisioned key solutions in the *integration of different modes* of transport, increased visibility in terms of cargo monitoring and available capacity. It was essential for participants to acquire the ability to forecast disruption scenarios and utilise artificial intelligence for the analysis and operational management of logistics processes. Special attention was paid to the emergence of *new actors in supply chains*, such as data brokers. Key challenges identified included potential difficulties in recruiting and training suitable specialists, the need to identify previously unknown threats, and increased cybersecurity risks resulting from the intensive exchange of data. Furthermore, despite high visibility and integration, longer and more complex supply chains can accelerate the spread of disruptions. It was also pointed out that harmonising regulations across Europe, while necessary to achieve true sustainability, may encourage market monopolisation.

The third vision, **Future Image 3**, assumed a low level of knowledge and preparation, but at the same time lower costs and fewer delays, achieved through a reactive and short-term approach. In this case, the most important priority for workshop participants was to *build flexibility and resilience* into the system by creating buffers, investing in research and development, and acquiring knowledge from external sources. The use of big data, artificial intelligence and data from unusual channels, such as social media and satellite data, took on great importance in the discussion. Companies in this vision will focus on short-term survival, protecting their ideas and solutions. The challenges identified mainly concerned the deepening polarisation of the market, the concentration of capital and knowledge, and growing protectionism. Participants emphasised that *companies are focusing on themselves and their local needs*, which limits cooperation and leads to a narrow strategic perspective. This vision also revealed a reluctance to share data, which may result in a lack of knowledge based on current sources

and the need to rely solely on historical data. This approach seems to lead to short-term responses, a lack of predictability and low competitiveness in the longer term.

An identified perception was that investments in the development of excessive capacity, a fleet of electric vehicles or charging infrastructure could often be carried out without a comprehensive overview of the system. It was pointed out that in the Future Image 3 scenario, a lack of system-wide knowledge and a purely reactive approach without a focus on long-term actions could result in the disappearance of companies that are unable to survive in a volatile market. It was also emphasised that, despite the measures taken, excessive investments made without a broader context may prove unsustainable and unprofitable. Attention was also drawn to the need for local control and monitoring and the simplification of bureaucracy through the restructuring and integration of competing entities.

The common message of all three Future Images is that access to knowledge and technology is not sufficient in itself. The dependency and links between data management quality, operational flexibility, cross-border cooperation and an appropriate regulatory framework are crucial. It is their synergy that will determine whether European logistics networks will be resilient and sustainable in the face of future disruptions.

3.4 Summary of Future Images Findings

Participants across all workshops, and their respective scenarios, consistently highlighted that resilience in transport and logistics systems relies on factors beyond technology or data. Effective disruption management requires robust governance, collaboration, and preparedness. At the regional level, stakeholders underscored the need for improved data quality and reliable data management systems, climate-conscious and well-coordinated planning, and balanced reliance on tools. National discussions reiterated the importance of collaboration, digitalisation, and continuous training, while cautioning against excessive bureaucracy and cybersecurity risks. At the global European scale, participants stressed that true resilience arises from the synergy between high-quality data management, operational flexibility, and harmonised regulations, underscoring that knowledge and technology alone cannot ensure sustainable and adaptable logistics networks.

4 Pathways: Results and Analysis

This section presents the main findings from the two Pathways workshops. The Pathways workshops were based on the Future Images findings, with the main goal to study how stakeholders can sustainably and resiliently respond to disruptions at the regional, national, and global level, without focusing on any single geographical area. Rather, the focus was on the different scales in the transport system. Furthermore, sustainability was a more central part of these workshops because previous findings indicate this as a key challenge stakeholders face (SARIL Project, 2024a; Svaboe et al., 2024).

4.1 Joint Platform Workshop

The first Pathways workshop focused on the concept of a Joint Platform, which served as a vision of an ambitious solution for improved sustainable resilience and as the basis for backcasting exercises. The concept of the Joint Platform emerged from the expressed needs of stakeholders during early-stage interviews and within the Future Images workshops to mitigate issues related to the fragmentation of information. Stakeholders indicated a need for enhanced data access, including both historical and real-time information, as well as improved data sharing, information flow, and tools to exploit the data availability to support more effective disruption management and decision-making across the logistics and transport sectors. Thus, the workshop explored its potential design and identifying the tools, actions, and prerequisites required within such a Joint Platform concept, encouraging future-orientated thinking towards ambitious solutions for green resilience.

The vision presented at the workshop was:

> *A publicly owned Joint Platform for publishing information and offering tools across different transport sectors and levels to address disruptions – including how to prepare and respond with real-time information and predictions, as well as other solutions and mitigation options.*

The Joint Platform concept could have many implementations, for example from a centralised solution to widely federated configurations. Within the workshops, the concept is used as a conceptual device to elicit stakeholder perspectives and identify requirements that can guide future solution development. The main findings from discussions on the vision are outlined below. Key topics in the discussions included organizational frameworks, data requirements, existing and future tools, demand for tool outputs, user-friendliness, potential users of the platform, and ethical considerations. In general, environmental sustainability was discussed as a strategic-level concern, with suggestions that the Joint Platform could promote sustainable choices through information provision and behavioural nudging, although it received less emphasis in the mini-survey we completed, compared to other mitigation measures.

The usage and requirements of tools differ among various stakeholder groups. Currently, many organizations lack tools, relying heavily on experience. However, some already possess tools that could incorporate new data sources and/or be updated. Certain stakeholders require a route planner, while others seek forecasts for planning future transportation systems. A distinct disparity exists between, for instance, drivers (operational level) and those in strategic roles. Nonetheless, the operational level relies on support from the strategic level.

Data sharing poses a challenge among organizations, partly due to geopolitical issues, competition, and the confidentiality of information between entities such as terminals and ports, which complicates the exchange of relevant updates on current situations. Additionally, regulatory constraints hinder data sharing. Stakeholders have expressed a need for incentives to facilitate information sharing and

cost-effective systems; if data sharing is practical and not overly expensive for businesses, it may proceed more smoothly. There is also a "give and take" dilemma that must be resolved; some stakeholders have noted that transport planning and management systems do not share data, either due to competitive concerns amongst individuals/organisations or software compatibility issues. Thus, future systems for data sharing must become more receptive and adaptable to receiving data from organizations and offer a competitive edge to users. Stakeholders indicated that the more transparent and formal the approach, the better; recommending that a Joint Platform with a data-sharing component should be managed by decision-makers to comply with regulations.

The requirements and expectations for a Joint Platform differed across organizational levels and stakeholder categories. For instance, real-time data holds greater significance at the operational level where swift decision-making is essential. Participants noted that the operational level does not necessarily require forecasting. Some suggested that predictive systems are vital, particularly if they are developed through an iterative approach. Additionally, although the quality of predictive functions may vary, they are primarily utilized to assist trucks in optimizing routes. These stakeholders emphasized the need for real-time data. However, different organizational levels have distinct needs, and forecasting remains essential at the strategic level and in research contexts. For those focused on predictions and forecasting, data harmonization and the necessity for updates on aspects such as vegetation and weather data are crucial, as e.g. many maps are outdated.

Data quality was a significant topic of discussion, with most stakeholder types underscoring its importance. For predictions, clear communication regarding the uncertainty of forecasts is vital to accurately evaluate data quality and reliability. This is particularly critical for analyses that inform long-term decision-making. The data requirements also differed based on their intended use. High-quality predictions necessitate historical data, with and without disruptions. Conversely, high-quality data for responding to disruptions (decision-making) must be reliable and readily available, meaning real-time operational data on issues like delays is essential. In simple terms, delayed data equates to poor data. Ideally, information should be refreshed daily.

Despite the diverse needs and expectations regarding the Joint Platform, stakeholders agreed that the Joint Platform must be interactive and well-integrated with existing tools to ensure its usefulness and avoid underutilization. They also emphasized usability, i.e., the need for clear, relevant, and efficiently transferable information, as key to promoting its adoption. Specific to tool integration, there was a discussion about enhancing existing transport management tools to improve predictions, for example by aggregating and synthesising existing information sources, including real-time information, rather than creating entirely new tools. Stakeholders noted that prediction accuracy could be improved through iterative process design. Meaningful usage was highlighted as important to stakeholders and included addressing topics such as expanding capabilities using both traditional and new data sources (e.g. social media) and associated risks.

The Joint Platform should also consider multimodality and provide multi-modal options. Stakeholders recognized the complexity of synchro-modal transport systems. For instance, if ships fail to arrive on time at a port, it can have significant disruptive consequences. Understanding how rail transport is affected in such scenarios would be beneficial for ports engaged in multimodal transport.

Some participants emphasized the primary need to aggregate existing data, meaning collecting and synthesizing information from various sources rather than developing new tools. For example, they explored the potential of analysing unstructured data, such as social media and news media, to gain insights into ongoing social, political, and civil unrest and strikes, including the behaviours leading up to such events. However, this analysis would require data quality assessments to ensure the reliability

of sources. Overall, social unrest as a disruption received considerable attention during the Joint Platform workshop. The L-PIT tool, as presented in this workshop, was suggested to potentially be further developed to investigate such disruptive occurrences.

Other disruption-related information needs included insights on weather-related events tied to seasonal changes. As weather significantly impacts delays, weather information is generally vital for decision-making. Furthermore, there is a demand for information on cascading effects and interdependencies. Many stakeholders agreed on the importance of focusing on key corridors, including ports and terminals handling major goods streams, such as Hamburg, Rotterdam, and Bremen. Additionally, stakeholders expressed the desire for a Joint Platform that assists in managing disruptions and enhancing their resilience, including regulatory resilience.

AI was discussed as a component of the solution within a Joint Platform. However, stakeholders also raised concerns about how AI could introduce new challenges and risks. Concerns have been raised regarding the potential for AI to mislead or act inappropriately. Ethical concerns were raised regarding AI use in the platform, particularly around accountability for AI-generated decisions. A particular worry related to AI and associated risks involves the management of data and the control over results. For instance, when an AI generates a prediction for decision-making, who is responsible for overseeing the analysis? Additional ethical issues surrounding the Joint Platform include group-specific interpretations having unfortunate side-effects, political instability, and matters related to aerospace and defence.

The topic of environmental sustainability received limited attention, which was also evident in the mini-survey (see Figure 4.1.). Some operative stakeholders characterized sustainability as an issue that is challenging to address at the micro level, such as within individual organizations. Instead, it is viewed as a matter requiring strategic-level decisions. A time-related aspect is also involved; disruptions are seen as urgent events needing immediate resolution, whereas sustainability is regarded as a long-term objective. Consequently, environmental sustainability was primarily discussed in relation to predictions, such as the analysis of sustainability indicators. There was also a discussion about the responsibilities across organizational levels and whether an integrated system from the upper/strategic level should be established to facilitate environmentally friendly actions at the operational level during disruptive events. Furthermore, there was a discussion on how environmental sustainability could be integrated into the Joint Platform in two ways:

1. Providing information (such as emissions, land use, and impact assessments).
2. "Nudging" organizations, meaning the platform would encourage sustainable choices, such as preferred routes and modes.

The mini-survey asked workshop participants to identify key mitigation measures to include in the Joint Platform, giving insights into their resilience priorities and needs. Figure 4.1 presents the results, with measures grouped into the following categories, represented by different colours: alternative transport and route adjustments (orange), collaboration and communication (yellow), tracking and monitoring (green), operational management (red), modelling (blue), data and digitalization (purple), and preventative planning (navy blue). The measures presented in the survey were derived from interviews, surveys and workshops concerning the Future Images.

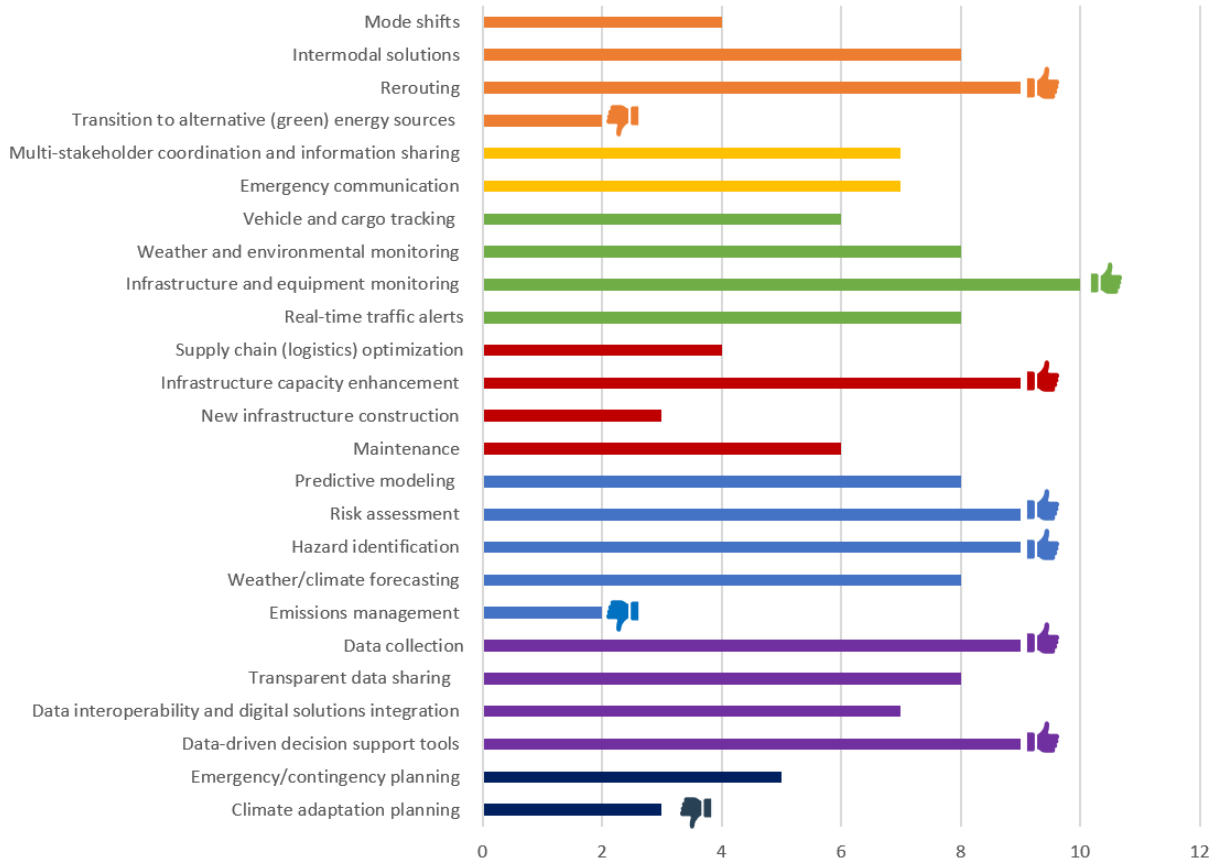

Figure 4.1: Joint Platform Workshop participant responses to "What mitigation measures should be included in the joint platform?" (N=14)

Respondents were asked to select all relevant mitigation measures, with the most popular measures in the mini-survey being:

- Infrastructure and equipment monitoring
- Infrastructure capacity enhancement
- Rerouting
- Hazard Identification
- Data collection
- Data-driven decision support tools
- Risk assessment

These measures were distributed among the mitigation categories and further distributed over the preventative/preparedness phase and the response phase of resiliency.

Further, the lowest ranked mitigation measures to be suggested for inclusion in a joint platform all related to environmental sustainability:

- Transition to alternative (green) energy sources
- Emissions management
- Climate adaption

4.2 Sustainability Workshop

During the second Pathways workshop, stakeholders working at strategic and operative levels in their organizations discussed sustainability, addressing associated challenges and opportunities, potential future solutions, and the role of the SARIL toolkit in this context. Generally, in times of disruption, economic factors and costs take precedence. This observation aligns with previous findings (Svaboe et al., 2024), and was reiterated by stakeholders in the first Pathways workshop, including in the mini-survey. In a crisis, primary concerns include minimizing delays, mitigating economic risks, ensuring cargo safety, maintaining client satisfaction, managing insurance (to cover additional costs), and reducing economic losses and fuel consumption. However, actions taken to alleviate these economic concerns can sometimes adversely affect long-term environmental objectives, as environmental considerations may be overlooked during crises. Consequently, workshop participants discussed barriers and drivers for integrating environmental sustainability into future disruption management planning. The results of the mini-survey from the first workshop served as a tool to initiate discussions on environmental sustainability. We first present workshop findings on the sustainability aspect, including stakeholder variation, drivers and barriers. Then, we present key stakeholder input on tools and data.

The strategic and operative levels in both logistics organizations and public authorities face distinct challenges, yet they are interdependent. Therefore, identifying potential connections between these levels could facilitate the development of future sustainable solutions. The operative level relies on investments, regulations, and legislation from the strategic level to make environmentally sustainable choices during disruptions; hence, the strategic level must support the operative level in formulating strategic backup options. Furthermore, addressing disruptions promptly is crucial. Currently, sustainable options are limited during crisis situations. Thus, a systemic change is essential for establishing robust sustainable operations, and proactive planning for sustainability is imperative. The strategic level can assist the operative level in becoming more sustainable by offering options for managing disruptions, such as renewable energy alternatives to reduce emissions. However, it is vital that the sustainable system is robust. Thus, synergies and trade-offs must be addressed to achieve both sustainable and resilient disruption management. For example, for logistics companies, there appears to be a trade-off between being fast, sustainable and reliable. There is a majority opinion that changing baseline operations is necessary to incorporate environmentally sustainable options, and that the system needs to be robust, i.e. function when disruptions occur for it to be accepted at the operative level. To identify future solutions for combining resilience and sustainability, stakeholders were asked to discuss drivers and barriers for implementing sustainable solutions for disruption management. Identified **drivers** and **barriers** for incorporating environmental sustainability in future planning for disruption management are presented in Table 4.1.

Table 4.1 Drivers and barriers for incorporating environmental sustainability.

Barriers	Drivers
• **Cost Sensitivity:** High upfront investments in green infrastructure. • **Short term focus:** Long-term needs and plans are overlooked when a disruption occurs. There is a lack of sustainable options for disruption management "on hand" for some operative stakeholders due to e.g. lacking sustainable investments, infrastructure, etc. • **Regulatory fragmentation:** Existing regulations and legislation are not developed in a way that makes environmentally sustainable choices viable and relevant options when a disruption occurs, indicating a need for sustainability to become a more prominent issue. Further, there is an absence of incentives and cross-border solutions. • **Analytical fragmentation:** Impact variations make planning for disruptions challenging as disruptions are dynamic and context-dependent (e.g. geographical diversity). Varying metrics for defining sustainability complicate quantification, measurement, and assessment of progress. • **Collaboration issues:** "Stakeholder complexity" within networks of competitors and collaborative relationships affects data sharing and information flow, thereby influencing decision-making and available opportunities. • **Limited Fuel/Energy Availability in Maritime Transport**: Challenges in implementing hydrogen projects and other sustainable initiatives. • **Geographical and infrastructure challenges**: Transitioning to lower emission modes is particularly difficult in certain regions, such as Africa.	• **Shift to lower emission modes through policy, regulations and legislations:** CO2 pricing and emission calculations are already influencing transportation decisions and planning. At the same time, policy measures are accelerating the electrification of transport, coupled with increased taxation on less sustainable transport options. • **Digitalization** aimed at reducing carbon footprint: Enhancing digital tools for prediction, response and rerouting, digitization can support route optimization to lower emissions and improving response times during disruptions, thereby mitigating their impact. • **Resilience through self-sufficiency:** Investment in self-production and renewable energy, such as solar panels and ports providing clean energy options, can increase resilience and environmental sustainability. It is important that renewable energy sources do not compromise contingency plans (i.e. are robust) • **Energy-efficient buildings through policy, regulations and legislations:** Adoption of energy-efficient buildings and BREEAM[5] certifications. • **Energy-efficient driving**: Implementing eco-driving practices for reducing fuel costs as well as reducing environmental impacts. • **Inter-modality** and opportunities for interconnected transport chains across various modes affects the scope of action, allowing for flexible use of terminals and alternative options/choices in the event of disruptions, as well as planning for various measures.

[5] Building Research Establishment Environmental Assessment Methodology (BREEAM)

Although sustainability was the main topic of the workshop, data and tools was also discussed in the second Pathways workshop. Interestingly, stakeholder variation was also reflected in the discussion on data and tools. From a decision-making perspective, the operative level relies on real-time information regarding routes, delays, goods (e.g., containers), and transportation infrastructure (e.g., rail data). To these stakeholders, real-time information is critical for making timely decisions and sharing event-related information. As such, real-time information is utilized more frequently at the operative level than planning tools. Conversely, the strategic level depends more on planning tools for prediction and simulation. Thus, data and tool needs are dependent on stakeholder types. Nonetheless, these tools can still be beneficial for the operative level by providing insights into the likelihood and severity of disruptions.

During the discussion on tool utility, the stakeholders suggested that tools can contribute to:

- **Training:** Tools can be employed to educate, inform, and prepare operative stakeholders prior to disruptions. Simulation, in particular, is a valuable method for examining potential events and evaluating the impact of decisions.
- **Increasing reliability of cargo flow:** Stakeholders expressed interest in tracking loads and optimizing flow to minimize cargo travel time and costs. There is a demand for tools that provide information on cargo flow, particularly at terminals, to prevent situations where loads become "stuck".
- **Route planning:** Predictive and rerouting tools can enhance environmental sustainability by reducing emissions. Route planning is mainly relevant for the strategic level.

Other tool improvement suggestions include improving **tool flexibility** by

- Incorporating additional transportation modes, as current tools are predominantly road-based.
- Improving data sharing and availability of data.
- Creating standardization to improve cross-tool compatibility/tool integration possibilities.
- Allowing for integration into existing management systems and internal IT tools to ensure seamless operation and utilization of the tool within the current workflow.
- Incorporating sustainability decision-making support into tools by providing insights on balancing cost-efficiency with environmental sustainability, ensuring that environmentally sustainable choices are economically viable.

Overall, disruptions are understood as “the new normal”, and stakeholders want and need tools that aid them in planning and reacting in a resilient and sustainable manner.

4.3 Summary of Pathways Findings

The first Pathways workshop centred on a publicly owned Joint Platform that aggregates and shares high-quality, real-time and historical data (for forecasting) across modes. A joint platform was found to be more useful if it integrates with existing tools and caters users from operative to strategic levels, while also addressing barriers related to data-sharing, governance, interoperability, and ethical considerations, particularly in the context of AI. This understanding is complimented by the insights on priorities identified in the mini-survey, which skewed toward practical resilience measures, including monitoring, capacity enhancement, rerouting, hazard identification, data collection, decision-support, and risk assessment. Sustainability-focused measures ranked lowest, underscoring the importance of exploring ways to better prioritize sustainability. During the dedicated Sustainability workshop, stakeholders noted that disruptions push cost and continuity to the foreground, so environmental aims require strategic-level policies, investment, and robust options that still work

under stress. In summary, with disruptions seen as “the new normal,” stakeholders want interoperable, user-friendly tools that combine real-time operations and planning analytics, making sustainable choices not only ideal but also viable during crises.

5 Discussion

The following section considers the findings of the series of workshops from a holistic perspective, examining their implications for our understanding of how solutions and strategies for sustainable resilience are developed, and what is required on the path toward a more sustainable and resilient future.

While the Future Images and Pathways workshop series had different focuses and examined the context of sustainable resilience within different contexts, stakeholders in both workshop series conveyed on several overarching themes that are important for the development of future solutions and strategies to address disruptions, as presented in Table 5.1

Table 5.1 Key findings across workshops (Future Images and Pathways).

Overarching topics	Description of key findings
Data and Technology	• (Access to) Updated data is critical for valid predictions and forecasts. • Data sharing and exchange are essential, e.g. for efficiency, safety, tracking. • Users demand integrated solutions to respond to multiple disruptions simultaneously, e.g. through one system or app. • AI, machine learning and digitalization are useful tools to deal with large amounts of data. • Social media represents a potential new source of both information and misinformation. • Concerns related to digitization and data sharing – e.g. cyberattacks and unfortunate side-effects of overreliance on technology. • Historical data is crucial during digital disruptions or, in general, for improving models/tools at the strategic level and within research. • Real-time data is crucial at the operative level as prompt reaction to events is needed.
Inter-relational or institutional	• Collaborations when facing disruptions must be enhanced, e.g. collaboration related to cybersecurity issues. • Need for reducing bureaucracy, both for regular operations but also for new businesses into logistics and transport networks, and for improving collaboration when disruption events occur.
Organisational	• Continuous training and awareness in organisations are required, e.g. multiskilling, system back-ups, risk awareness, highlighting the important role of risk managers.
Systemic change for Sustainability	• Governance and flexibility of the system are vital for achieving resilience. • The operative level needs support from the systemic level to become more sustainable long term. • Raising awareness of the importance of sustainability integration is crucial in disruption management, and the benefits would also be social and economic. • Public sector must play a leading role by coordinating efforts, regulating and creating standardizations that nudge towards environmentally responsible solutions, and by implementing policies that incentivize sustainable behaviour.

Considering the development of tools and use of data to improve sustainable resilience, several key points stood out. First, enhanced data sharing is essential. Stakeholders suggested data harmonization through a single 'point of contact' could ensure access to reliable information and promote intermodal solutions, while some also pointed out the need for data brokers to ensure data flow. However, this introduces new challenges, including increased cybersecurity risks associated with greater volumes of data flow, as well as stakeholder complexity and competition, which can hinder collaboration and jeopardise data sharing across the sector. Second, users, primarily at the strategic level, want the possibility to respond to several different disruptions simultaneously, for example through a simple system or application. In practice, disruptions rarely occur in isolation; weather events, infrastructure failures, and supply chain bottlenecks often coincide or trigger cascading effects across networks. However, managing disruptions is a complex issue, and effective response depends on technological as well as organizational maturity and strong cross-organisation collaboration. Therefore, solutions should prioritise the integration and interoperability of diverse tools to enable coordinated responses to complex disruptions, specific to the needs of the distinct user groups (i.e., public infrastructure managers and logistics strategic managers). Achieving this will also require improved data sharing frameworks. Third, the capacity to handle disruptions and integrate new tools varies within logistics and transport organisations. The workshop discussions revealed differences between stakeholder types in terms of needs, experiences, and resources for handling disruptions. Therefore, it is necessary to differentiate between the requirements of actors operating the strategic level and those at the operative level (i.e. ´on the road´), where future solutions should accommodate these individual needs while strengthening the connections and interdependencies between levels to ensure coherent, system-wide resilience.

The above points have implications for the development of solutions such as the SARIL tools, and several of these aspects have already been addressed within the project's ongoing developments. The project has established several roles for stakeholders (see D1.2 for further details (SARIL Project, 2024c), including one aimed at logistics strategy management and another at logistics operational management, representing strategic and operative needs. Tools within SARIL have been developed for these roles, and associated requirements, in mind. Further, within the individual scenarios (regional, national, European), SARIL aims to integrate tools and share data between them. The integration of tools within the European scenario (as described in 2.2.1) illustrates this well, where the Disruption Information Interface collects and shares historic disruption data with the ASTROIT tool, which simulates the impacts of predicted disruptions and possible mitigation strategies. Further integration occurs with the Energy Module, which supplies energy and emissions indicators for routing solutions generated by ASTROIT, feeding this information back into ASTROIT, allowing users to compare not only delivery times and costs, but also CO_2 emissions and energy consumption between the routing alternatives. This integration represents an important step toward improved data sharing and more integrated functionality across different types of disruption events, while also embedding sustainability considerations through the inclusion of emissions metrics and aligning with stakeholder priorities identified during the workshops. However, while the first Pathways workshop was framed around a vision of a Joint Platform, given stakeholders desire for a publicly owned, integrated service interface, the practical implementation of such an integrated solution is likely to take the form of a federated network of platforms that support data sharing between organisations and tools/solutions, as recommended by the Digital Transport and Logistics Forum (DTLF, 2018)and previous EU project such as FEDeRATED (FEDeRATED, n.d.). Nevertheless, the stakeholder requirements identified in the co-creation activities for an integrated solution still remain valid.

The involvement of tool developers in the workshops provided opportunities for them to discuss directly with stakeholders during breakout sessions. Upon reflection, we found that tool developer

involvement could have been exploited even more to enhance the dissemination of tools to stakeholders, highlighting the benefits of interdisciplinary collaboration. As such, including tool developers more actively and at an early stage of the co-creation activities should be considered in future projects.

Beyond the direct development of the tools, workshop results also underscored the importance of coordination and collaboration among authorities within planning and training for disruption response, as well as the need to reduce bureaucratical barriers that hinder such collaboration. Stakeholders emphasized the creation of synergies between technology, information, and human capabilities, supported by organizational strategies. While technological solutions are essential, they alone are insufficient to achieve the SARIL vision; success also depends on system adaptability and effective collaboration across actors and levels. Co-creation processes play a critical role in aligning technological, organisational, and human dimensions, ensuring that resulting solutions are both context-sensitive and collectively supported.

The workshops also provided insight that the sustainability aspects of the “green resilience” vision were often not at the forefront of the stakeholders’ agenda during disruptions, where stakeholders were most focused on fulfilling obligations despite disruptions in the fastest and cheapest way. This was seen, for example, in the response to mini-survey where workshop participants ranked sustainability-related mitigation measure as least important for inclusion into a joint platform vision. Discussions within the Sustainability Pathways workshop, which focused on how sustainability could be better integrated into resilience solutions, highlighted the relationship between the operative and strategic components of stakeholder organisations, particularly the dependence of operative stakeholders on strategic-level support to implement long-term sustainable solutions. Such interdependence is often a key enabler of systemic change, which is necessary to facilitate broader transformations toward more environmentally sustainable solutions at the operative level. For example, as discussed within the workshop, to make environmentally friendly investments, the operative level requires regulatory frameworks that support environmentally friendly practices, legislation that encourages sustainable activities, and more focused subsidization programs from the strategic level. Operative stakeholders are already changing practices due to, for example, CO_2 pricing and taxation, indicating their capacity to adapt and transition towards more environmentally friendly practices and adapt transition to more low-emission modes and technology investments, including implementing eco-driving schemes, electric vehicles or even renewable energy investments. However, a greater push from the strategic level is necessary to meet international climate and nature goals. Since the ‘wiggle room’ for action (and non-action) can vary between stakeholder types, the interconnectedness and dependencies between levels should be considered when working on future solutions for sustainable and resilient operations.

6 Conclusion

Deliverable 1.4. summarizes the key findings from two co-creation workshop series based on participatory foresight methodology. In the *Future Images* workshops, stakeholders explored possible future outlooks across three scenarios/scales with varied levels of available information and management costs of disruptions. *Pathways* workshops were used to further explore key topics such as the relationship between sustainability and resilience, data sharing and availability, and usefulness of tools.

Through the application of foresight methods, including backcasting from the envisioned integrated platform concept, these insights have been translated into a set of proposed functions and attributes that can guide solution development, including:

- Integration of data from multiple sources and data sharing.
- Support for real-time decision-making and strategic planning.
- Promotion of sustainable choices through behavioural nudging.
- Public development for increased interoperable and adaptability across organisations and organisational levels.

The workshops supported understandings that stakeholder type and associated needs must be carefully considered when developing strategies and solutions that are both resilient and sustainable. While this is not a new finding, it is relevant for the development of a suite of complementary tools. For instance, actors at the operative level require simple and fast tools to support immediate decision-making, whereas those at the strategic level benefit from simulation tools that inform long-term investment decisions. In identifying relevant user groups for each tool, the SARIL toolkit aims to ensure that these differing needs are addressed.

Further, SARIL aims to enhance green resilience, yet within the workshops, stakeholders indicated that environmental sustainability often becomes a secondary priority during crises, where the focus shifts toward maintaining operational continuity and mitigating economic losses. This need for systemic change is common across similar sustainability transformation efforts.

The purpose of the workshops was to generate new knowledge of responses to disruptive events, and on approaches to resilience and sustainability to develop solutions for future logistics and transport. As a key component of participatory foresight methodology, the inclusion of a wide range of stakeholder types strengthens the holistic understanding of the challenges and opportunities facing the transport and logistics sectors, supporting progress toward more sustainable and resilient systems in the face of disruptions. While the workshop series provided input into the development of resilience solutions, particularly the SARIL tools, technology is not all that is needed to reach resilience and sustainability goals. The workshops highlighted the importance of planning, collaboration, governance and flexibility for enabling systemic change. Developing the participatory foresight method together with the consortium and continuous refitting of method, was essential to gather critical knowledge on stakeholder needs and their visions for an improved future.

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Appendix

A.1. Delphi survey topics and questions

1. Disruptions in the last 5 years:

Question: In your opinion, how much have the following disruptions affected your daily work in the last 5 years? Please answer on a scale from 1-5, where 1 is "Not affected" and 5 is "Strongly affected".

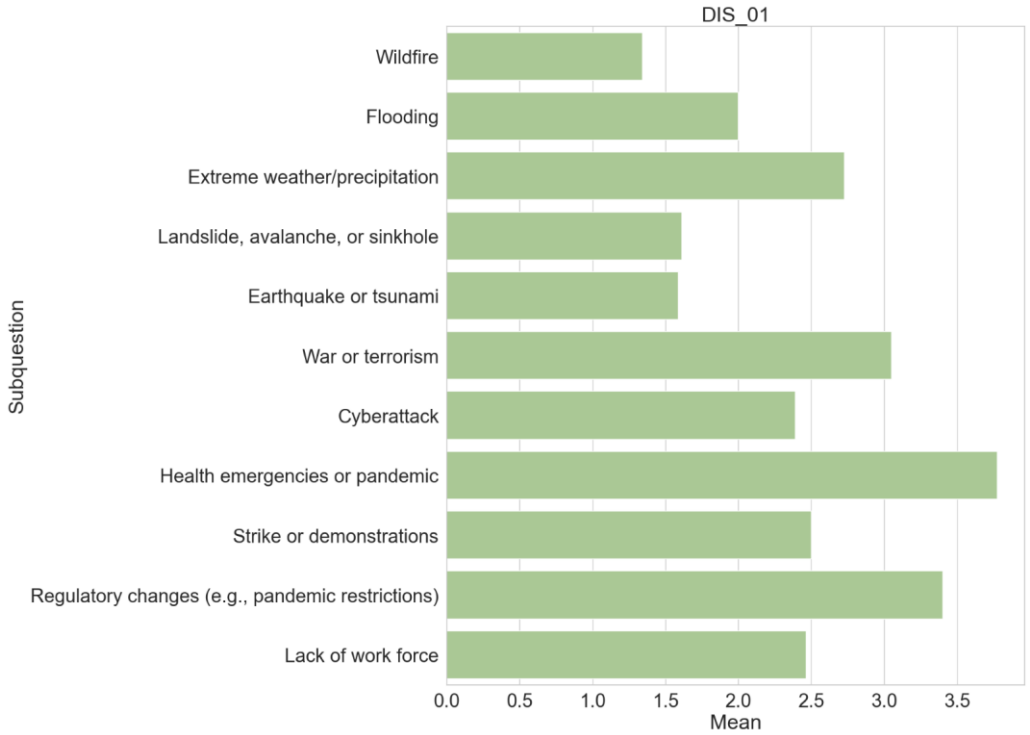

Figure A.3 Disruptions affecting daily work over the last 5 years

Figure A.1 shows the types of disruptive events the respondents have experienced over the last five years. Unsurprisingly, “health emergencies or pandemic” had the highest mean score. “Regulatory changes” and “War and terrorism” followed, with the second and third highest means (both have means over 3), indicating these are disruptions of high importance to the participants.

Overall, the disruptions with the highest means are related to human, policy or regulatory challenges. In contrast, nature-related disruptions such as wildfire, landslide, earthquake, etc. received lower scores in the Delphi-survey. Possible explanations include; 1) Stakeholders may have already developed handling approaches for nature-related events, 2) Pandemic, war, terrorism and regulatory issues have had greater impact in the past few years, or 3) the disruptions with higher mean scores are more unpredictable in effect and scope, i.e. are more “volatile”. Still, extreme weather/precipitation scored high, indicating that weather-related events are a challenging disruption for stakeholders.

2. Severity of the consequences of disruptions:

Question: Think about the type of disruption you were affected most by. Of the following potential consequences, how severe have they been? Please answer on a scale of 1-5 where 1 is "Not severe" and 5 is "Very severe".

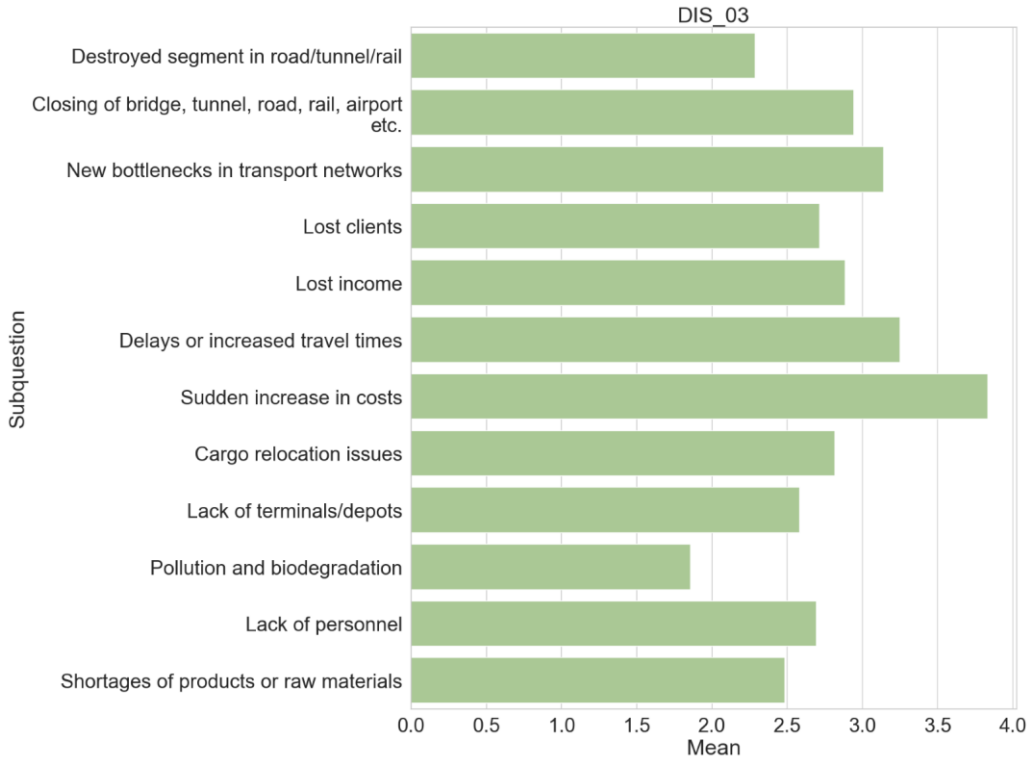

Figure A.4 Severity of consequences of disruptions

Figure A.2 shows the most severe consequences of the disruptions suffered, which were linked to a "Sudden increase in costs", with a means above 3.5, followed by "Delays or increased travel times" and "New bottlenecks in transport networks" with means rated above 3.5 and 3, respectively.

3. Availability of handling approaches:

Question: How available have the following handling strategies or solutions been during or right after a disruption? Answer scale from 1. Unavailable to 5. Easily accessible. N=39.

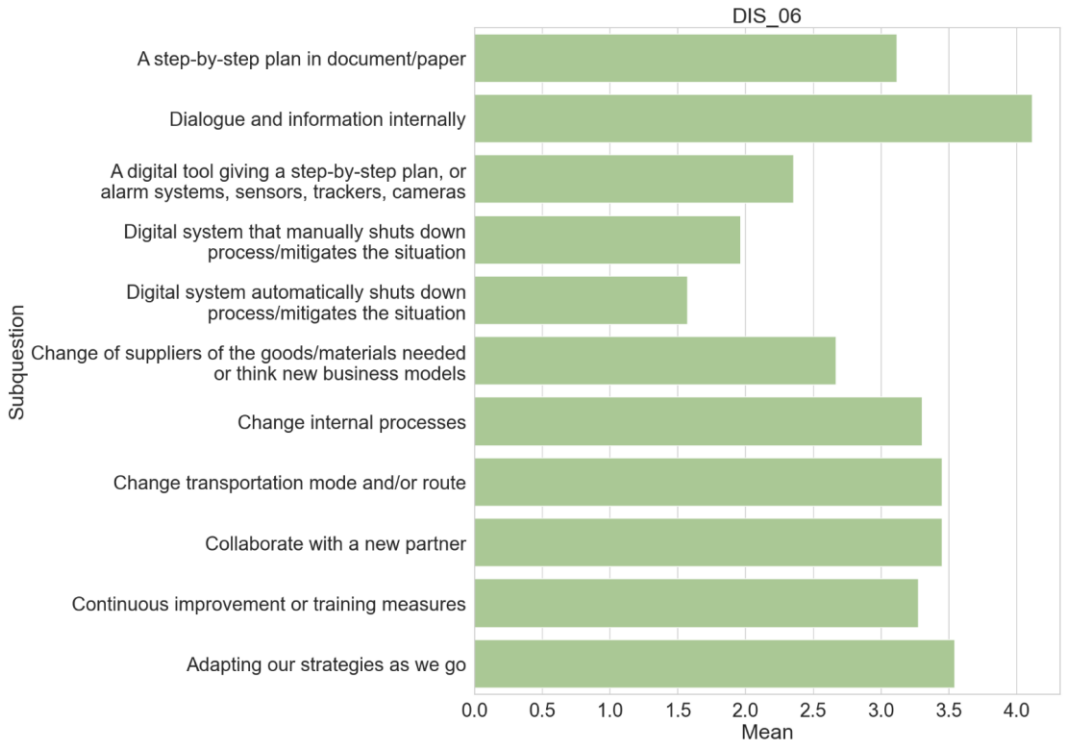

Figure A.5 Availability of handling approaches.

Figure A.3 depicts that “Dialogue and internal information” is by far, with a mean over 4, the most important aspect when considering the availability of handling approaches.

This is followed by other strategies rated between 3 to 3.5; “Collaborate with a new partner”, “Change transportation mode/route”, both with a mean of almost 3.5; “Change internal processes”, and “Step-by-step plan in document/paper", with a mean just over 3.

4. Barriers when applying handling approaches:

Question: Thinking back on the disruption that affected your daily work the most, how important are the following barriers in responding to disruptions? Please answer on a scale from 1-5 where 1 is “Unimportant” and 5 is “Very important”.

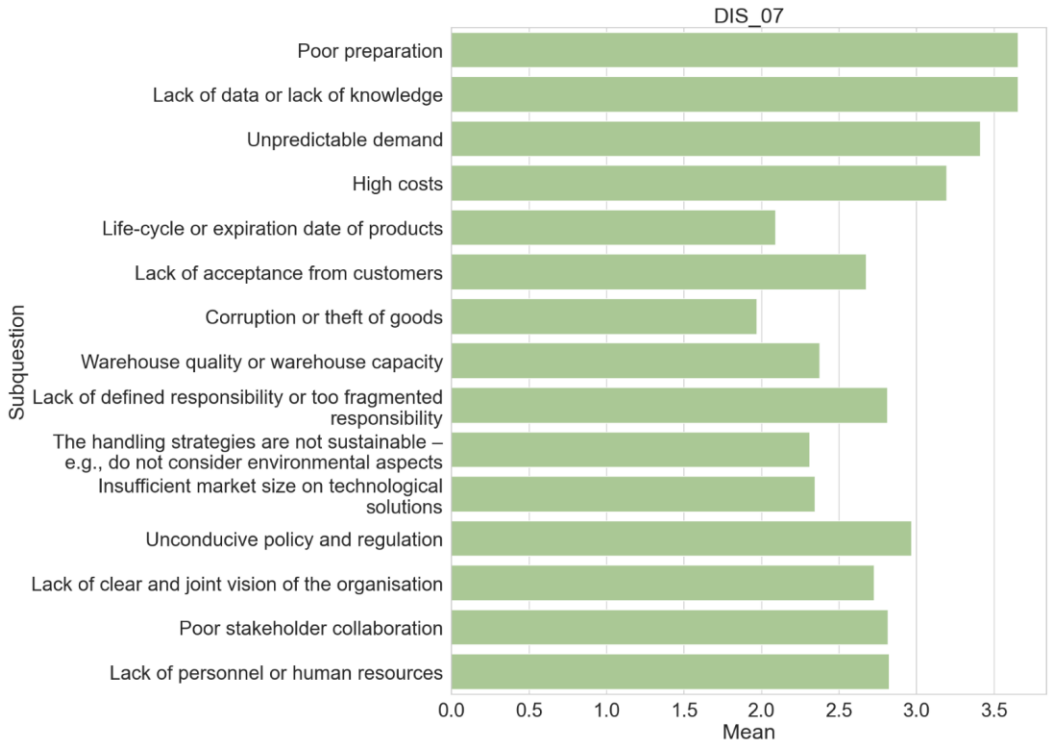

Figure A.6 Barriers to handling approaches

Figure A.4 shows that the main barriers for using handling approaches are “Poor preparation” and “Lack of data/knowledge”, both rating over 3.5 mean. This is followed by “Unpredictable demand”, with a mean near to 3.5 and “High costs”, rating just over 3 mean.

A.2. Future Images Workshop questions

A.2.1. Questions for Regional scenario workshop

In the *Regional scenario* workshop the groups faced 4 images.

The questions asked to the groups were:

- How would you manage disruptions in this future scenario within your transport area/system? What general measures and management strategies would you use in this future image for your transport area/system?
- What tools/models/technologies are in use/should be used and why? (What would you need from a tool/model to manage or predict disruptions for your transport area/system?)
- What would be the challenges and risks to mitigate disruptions (in addition to delays/costs in this future image) for your transport area/system?
- What data is shared and with whom to anticipate or address disruptions?
- What sustainability factors are considered in this future image in managing disruptions?
- What policies need to be in place to support disruption mitigation?

A.2.2. Questions for National scenario workshop

In the National scenario workshop group discussions were held on the current situation and on 2 future images.

Regarding the current status, the questions asked to the groups were:

- What **handling approaches** are applied *in your area/transport system/organisation*?
- Are there **tools/models/technologies** in use when disruptions occur? And how do they work?
- What are the **challenges and risks** to be able to mitigate disruptions *in your area/transport system/organisation*?
- What **data** is shared and with whom *for anticipating disruptions or for dealing with disruptions*?
- How do you include **sustainability** in your normal operations today? What, if any, sustainability factors are considered during disruption reactions?
- What **policies** are in place to support disruption mitigation?

Regarding the future images, the questions asked to the groups were:

- What **overarching handling approaches** should be used in this future image *for your area/transport system/organisation*?
- What **tools/models/technologies** for your area/transport system should be in use and why? (What would you need from a tool/model in handling or predicting disruptions)
- What are **challenges and risks** for mitigating disruptions (on top of delays/costs in this future image) *for your area/transport system*?
- What **data** should be shared and with whom *for anticipating disruptions or for dealing with disruptions in this future image?*
- What **sustainability factors** should be accounted for in this future image when handling disruptions?
- What **policies** need to be in place to support disruption mitigation?

A.2.3. Questions in European scenario workshop

First group discussion: Status today for mitigating disruptions

- How are disruptions handled today within *your area/transport system*?
- What **handling approaches** are applied *in your area/transport system*? (e.g. considering redundancy, reliability, flexibility, visibility, security, collaboration, recovery and learning.)
- Are there **tools/models/technologies** in use when disruptions occur? And how do they work?
- What are the **challenges** and risks to be able to mitigate disruptions *in your area/transport system*?
- What **data** is shared and with whom *for anticipating disruptions or for dealing with disruptions* ?
- How do you include **sustainability** in your normal operations today?
- What, if any, sustainability factors are considered during disruption reactions?
- What **policies** are in place to support disruption mitigation?

Second group discussion: Mitigation of disruptions in the future -what do you wish for?

- How should disruptions be handled in this future image within *your area/transport system*?
- What **overarching handling approaches** should be used in this future image *for your area/transport system*? (e.g. considering redundancy, reliability, flexibility, visibility, security, collaboration, recovery and learning.)
- What **tools/models/technologies** should be in use and why? (What would you need from a tool/model in handling or predicting disruptions) for your area/transport system?)

- What are **challenges and risks** for mitigating disruptions (on top of delays/costs in this future image) *for your area/transport system*?
- What **data** should be shared and with whom *for anticipating disruptions or for dealing with disruptions in this future image?*
- What **sustainability factors** should be accounted for in this future image when handling disruptions?
- (Some examples of sustainability factors could be:
- Using local suppliers (to avoid unnecessary transport)
- Using low-emissions vehicles and routes
- Minimizing waste and using resources efficiently.
- Using transport capacity to the utmost.)
- What **sustainability factors** should be accounted for in this future image when handling disruptions?
- (Some examples of sustainability factors could be:
- Using local suppliers (to avoid unnecessary transport)
- Using low-emissions vehicles and routes
- Minimizing waste and using resources efficiently.
- Using transport capacity to the utmost.)
- What **policies** need to be in place to support disruption mitigation?

A.3. Stakeholders in Future Images workshops

A.3.1. Regional scenario stakeholders

Organization	Organization description	Stakeholder type	Participants (n)
Truck Drivers Association	Truck Drivers Association	Associations/Representative organisations/NGO	1
Agenzia per la cybersicurezza nazionale Italiana	Italian national cyber security authority	Public authorities (others)	1
Italian Railway Network	Public company for managing the Italian railway infrastructure	Infrastructure owner or operator	3
ANAS	Roadway services, manager of roadways	Infrastructure owner or operator	1
Gruber Logistics	Logistics company	Logistics and transport management and operation companies	1
Lombardy Regional Office	Regional authority	Public authorities (others)	5

Politecnico di Milano*	University	Researchers/Consultants	6
RINA CONSULTING SPA *	Research institute	Researchers/Consultants	2
AiPO, AGENZIA INTERREGIONALE PER IL FIUME PO*	Public body that provides engineering and environmental services by the Po river across several Italian regions	Public authority (other)	1

*From Consortium

A.3.2. National scenario stakeholders:

Organization	**Organization description**	**Stakeholder type**	**Participants (n)**
Port Authority of Vigo (APV)*	Public port authority	Infrastructure owner and operator	3
Port Authority of Leixões (APDL)	Public port authority	Infrastructure owner and/or operator	1
Associação Portuguesa de Logística (APLOG)	Non-profit association that promotes logistics and supply chain management across Portugal	Associations/Representative organisations/NGO	1
MARLO*	Consulting and technology solutions to the transport and logistics sector	Researchers/Consultants and Technology solutions provider	1
Rangel Logistics Solutions*	Logistic solutions and tailored services	Logistics and transport management and operation companies	3
ATEIA	Association and representation of logistic operators and/or companies	Associations/Representative organisations/NGO	1

SUARDÍAZ	Logistic operators at the container port terminal	Logistics and transport management and operation companies	1
TERMICAR	Logistic operators at the container port terminal, sea freight of all types of goods	Logistics and transport management and operation companies	1
PROGECO	Handling operators for containers and freight transport at the container port terminal	Logistics and transport management and operation companies	1
TERMAVI	Handling operators for containers and freight transport at port terminal and Border Inspection Post (BPI)	Logistics and transport management and operation companies	1
KALEIDO	Handling operators for containers and freight at the container port terminal	Logistics and transport management and operation companies	1
FI-GROUP	Financial consultants for R&D projects	Researchers/Consultants	1
Babé & Cía.	Transport and supplier of hydrocarbons and petroleum products	Logistics and transport management and operation companies And End user of transport	1
Cluster de Función Loxística de Galicia	Sectorial association comprising organisations from all stages of the supply chain	Associations/Representative organisations/NGO	1
SINTEF*	Research institute	Researchers/Consultants	2
CEMOSA*	Research institute	Researchers/Consultants	1
University of Vigo*	University	Researchers/Consultants	2

*From Consortium

A.3.3. European scenario stakeholders

Organization	Organization description	Stakeholder type	Participants (n)
Hamburg Port Authority	Port Authority	Infrastructure owner or operator	2
Szczecin Świnoujście Port Authority	Port Authority	Infrastructure owner or operator	1
Szczecin University of Technology	University	Researchers/Consultants	1
CSL	Logistics service provider	Logistics and transport management and operation companies	2
DB Port Szczecin	Port Infrastructure Operator	Infrastructure owner or operator	1
Freightliner	Rail logistics service provider	Logistics and transport management and operation companies	1
Olavion	Rail logistics service provider	Logistics and transport management and operation companies	1
Gebrüder Weiss*	Transport and logistics company	Logistics and transport management and operation companies	1
DB Cargo	Rail logistics service provider	Logistics and transport management and operation companies	1
Police Chemical Factory	Chemical industry company	End users of transport	1
MAG	Logistics forwarding company	Logistics and transport management and operation companies	1
Polish International Freight Forwarders Association	Workers association within logistics	Associations/Representative organisations/NGO	1
SIEC BADAWCZA LUKASIEWICZ - POZNANSKI INSTYTUT TECHNOLOGICZNY*	Research institute	Researchers/Consultants	1
SINTEF*	Research institute	Researchers/Consultants	2
Rangel Logistics Solutions*	Logistic solutions and tailored services	Logistics and transport management and operation companies	1
Fraunhofer EMI*	Research institute	Researchers/Consultants	2

*From Consortium

A.4. Stakeholders in Pathways workshops

A.4.1. Joint platform workshop stakeholders

Organization	Organization description	Stakeholder type	Participants (n)
Tyrolean road rail transshipment hub and Rail Cargo Austria	Road and rail hub and representative of rail cargo division of the national Austrian rail company OEBB.	Infrastructure owner or operator	1
Port Authority of Leixões (APDL)	Port authority	Infrastructure owner or operator	1
Hafen Wien GmbH	Port authority	Infrastructure owner or operator	2
Norwegian University of Science and Technology	University	Researchers/Consultants	3
Grupo Gof	Owns several companies in trade of multiple goods, from raw materials and computer applications to port logistics services	End users of transport, mainly	1
Axega	Galician Emergency Agency	Public authorities (other)	1
Gebrüder Weiss GmbH*	Transport and logistics company	Logistics and transport management and operation companies	7
CSL*	Logistics service provider	Logistics and transport management and operation companies	2
UNIVERSIDADE DO MINHO*	University	Researchers/Consultants	1
Port Authority of Vigo (APV)*	Port Authority	Infrastructure owner or operator	1
CEMOSA*	Consulting and technology solutions to the transport and logistics sector	Researchers/Consultants	1
L-PIT, SIEC BADAWCZA LUKASIEWICZ - POZNANSKI INSTYTUT TECHNOLOGICZNY*	Research institute	Researchers/Consultants	1
SINTEF*	Research institute	Researchers/Consultants	7
Politecnico di Milano*	University	Researchers/Consultants	4
University of Vigo*	University	Researchers/Consultants	2
Fraunhofer EMI*	Research institute	Researchers/Consultants	2

Rangel Logistics Solutions*	Logistic solutions and tailored services	Logistics and transport management and operation companies	1
Marlo*	Consulting and technology solutions to the transport and logistics sector	Researchers/Consultants and Technology solutions provider	1

A.4.2. Sustainability workshop stakeholders

Organization	**Organization description**	**Stakeholder type**	**Participants (n)**
KALEIDO	Handling operators for containers and freight	Logistics and transport management and operation companies	1
Hafen Wien GmbH	Port Authority	Infrastructure owner or operator	1
University of Brescia	University	Researchers/Consultants	1
Transporeon GmbH	Transportation management platform	Technology solutions company	1
European Shippers' Council	Non-profit European organisation representing cargo owners	Associations/Representative organisations	1
UNIVERSIDADE DO MINHO*	University	Researchers/Consultants	1
CSL*	Logistics service provider	Logistics and transport management and operation companies	1
Gebrüder Weiss GmbH*	Transport and logistics company	Logistics and transport management and operation companies	3
Port Authority of Vigo (APV)*	Port Authority	Infrastructure owner or operator	1
ALICE, ALLIANCE FOR LOGISTICS INNOVATION THROUGH COLLABORATION IN EUROPE*	European Technology Platform ALICE, for research, innovation and market deployment of logistics and supply chain management in Europe	Associations/Representative organisations	2
L-PIT, SIEC BADAWCZA LUKASIEWICZ - POZNANSKI INSTYTUT TECHNOLOGICZNY*	Research institute	Researchers/Consultants	1
SINTEF*	Research institute	Researchers/Consultants	7
Politecnico di Milano*	University	Researchers/Consultants	1
University of Vigo*	University	Researchers/Consultants	1
Fraunhofer EMI*	Research institute	Researchers/Consultants	2

Rangel Logistics Solutions*	Logistic solutions and tailored services	Logistics and transport management and operation companies	3
MARLO*	Consulting and technology solutions to the transport and logistics sector	Researchers/Consultants and Technology solutions provider	1
RINA CONSULTING SPA*	Research institute	Researchers/Consultants	1