Towards Resilient & Intelligent Multimodal Transport Networks

(Results from EU Research Projects ReMuNet & SARIL)

- ReMuNet Project Presentation
- SARIL Project Presentation
- Panel Discussion
- Interactive Q&A Session

Funded by the European Union

ReMuNet
Pioneering resilient and adaptive multimodal transport networks

20.05.2026 – Towards Resilient and Intelligent Multimodal Transport Networks

1	Welcome & Opening Remarks	Octavia Stepan (CINEA)	13:00 – 13:10
2	ReMuNet Project Presentation - Building resilience in multimodal transport through digital innovation	Maximilian Dicks (FIR), Florian Krietsch (PTV), Dr. Sandra Stein (FHA), Ketki Kulkarni (HAN), Lasse Nykänen (VED)	13:10 – 14:00
3	SARIL Project Presentation - Strengthening resilience through collaboration, tools, and business innovation	Kris Schroven (EMI), Paula Lopez Arevalo, Marta Waldmann (L-PIT), Diana Noriega (Port Authority of Vigo), Mariusz Graca (CSL Sp. z o.o.)	14:00 – 15:00
4	Break & Networking		15:00 – 15:15
5	Panel Discussion - Resilient Multimodal Transport Networks: From Research to Real-World Impact	Alan McKinoon (KLU), Sophie Punte (Life-Links), Pablo Segura (ALICE), Sandra Stein (FHA), Florian Krietsch (PTV), Arnd Hoppe (Gebrüder Weiss)	15:15 – 16:00
6	Interactive Q&A Session	All	16:00 – 16:45
7	Closing Remarks & Next Steps	Maximilian Dicks (FIR), Kris Schroven (EMI)	16:45 – 17:00
8	Informal Networking	All	17:00 – 17:30

SARIL

European Climate, Infrastructure and Environment Executive Agency

ReMuNet & SARIL Final Event

Towards Resilient and Intelligent Multimodal Transport Networks

TRA 2026 / 20 May 2026

Octavia Stepan, Head of Sector Integarted transport and Cities
European Climate, Infrastructure and Environment Executive Agency

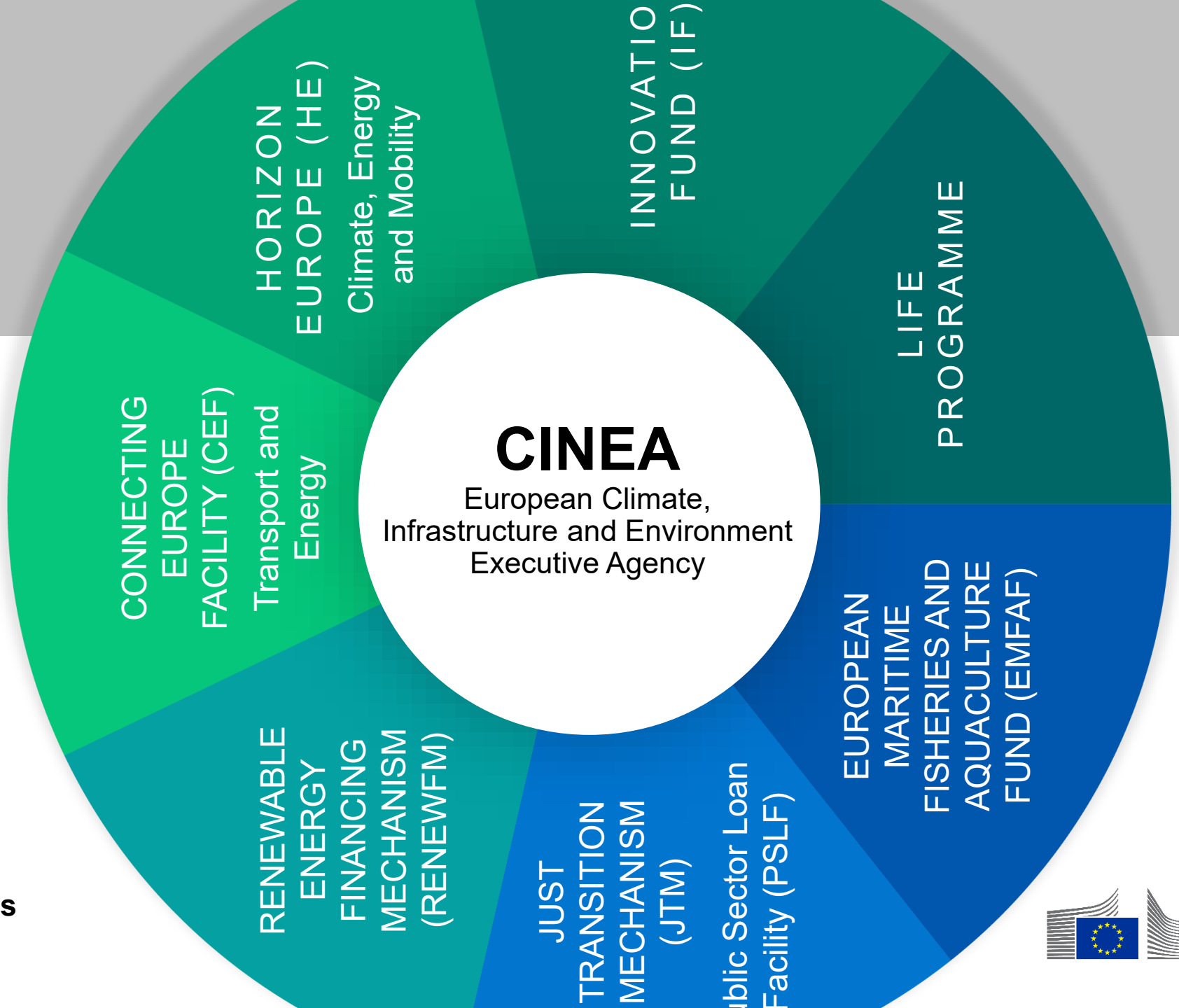
European Commission

Boosting green growth and clean industry in Europe

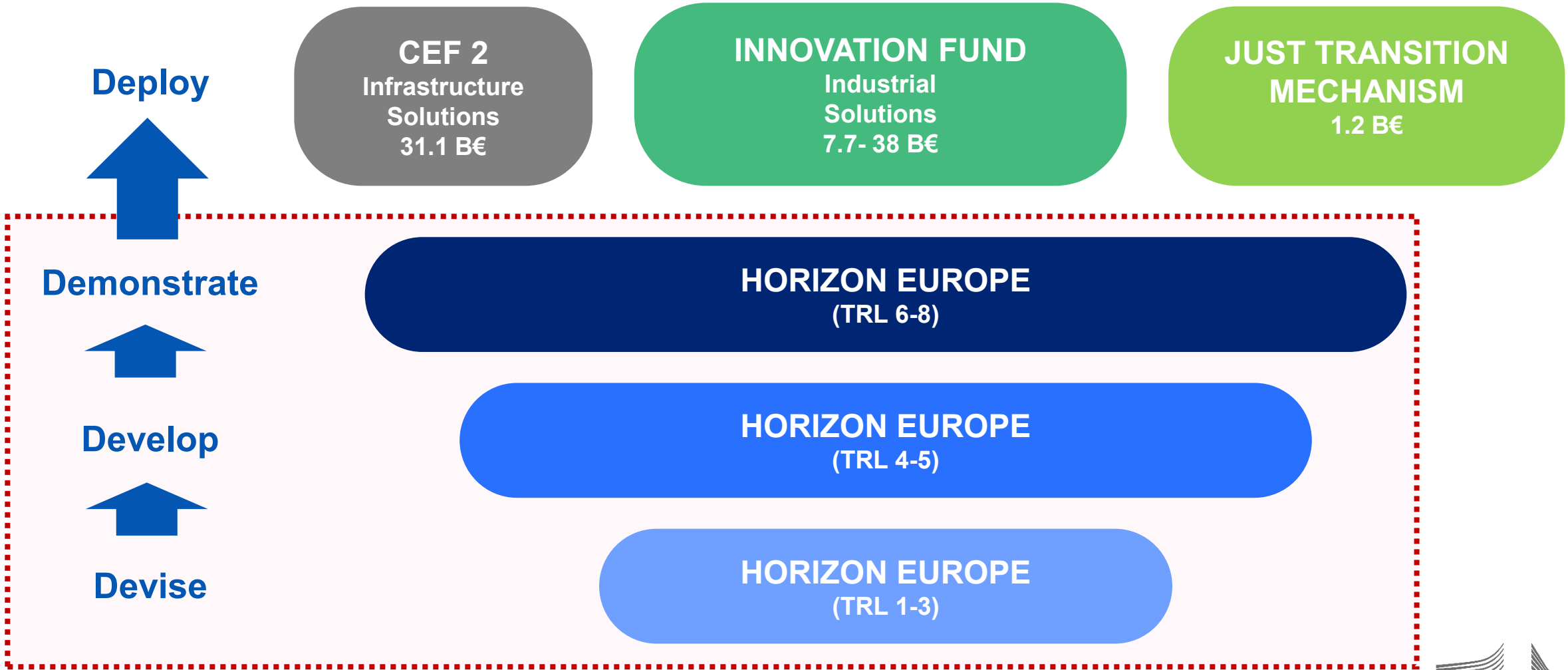
€67 billion
2021-2027

600+
Staff

3900
Ongoing projects



ALIGNING PROGRAMMES TO DELIVER SOLUTIONS



Examples: cinea.ec.europa.eu/system/files/2021-06/Exploitation_success_stories_H2020-2020_rev.pdf

5

LONG HAUL LOGISTICS

HORIZON-CL5-2022-D6-02-01: Logistics networks integration and harmonisation through operational connectivity to **optimise freight flows and drive logistics to climate neutrality**

ADMIRAL & TRACE

TRACE inTegration & haRmonizAtion of logistiCs opErations

ADMIRAL

HORIZON-CL5-2022-D6-02-07: New concepts and **approaches for resilient and green freight transport** and logistics networks against disruptive events (including pandemics)

ReMuNet & SARIL

SARIL

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HORIZON-CL5-2022-D6-02-03: **Smart enforcement** for resilient, sustainable and more efficient transport operations

KEYSTONE & SETO

KEYSTONE

SETO Smart Enforcement of Transport Operations

HORIZON-CL5-2024-D6-01-07: Scaling up logistics innovations supporting **freight transport decarbonisation** in an affordable way

IKIGAI & HOLOGISTICS

IKIGAI

HOLOGISTICS
INNOVATIVE TECH FOR GREENER CARGO

European Commission

Topic description and requirements

New concepts and approaches for resilient and green freight transport and logistics networks against disruptive events

Expected Outcomes

- **A multimodal EU freight network** (incl. international connections) **capable of rapid, seamless response to disruptions**, with **reduced emissions and shorter recovery times**
- **Freight networks resilient by design**: **real-time data, pre-defined alternative routes, synchromodal approaches, and secure digital logistics tools**
- New **cost-efficient, zero-emission business models** adopted by the sector in the short-to-medium term, **backed by appropriate regulatory frameworks**

Topic description and requirements

New concepts and approaches for resilient and green freight transport and logistics networks against disruptive events (including pandemics)

ReMuNet

- **Real-time operational platform for synchromodal disruption** management across road, rail and inland waterways
- Directly addresses synchromodal approaches, **pre-defined alternative routes, real-time digital tools, corridor performance intelligence**
- Positioned as **a Physical Internet trailblazer**: open, interconnected, shared logistics network
- **Two pilot corridors – North Sea–Baltic and Rhine–Danube** – with focus on practical deployments along with industry partners

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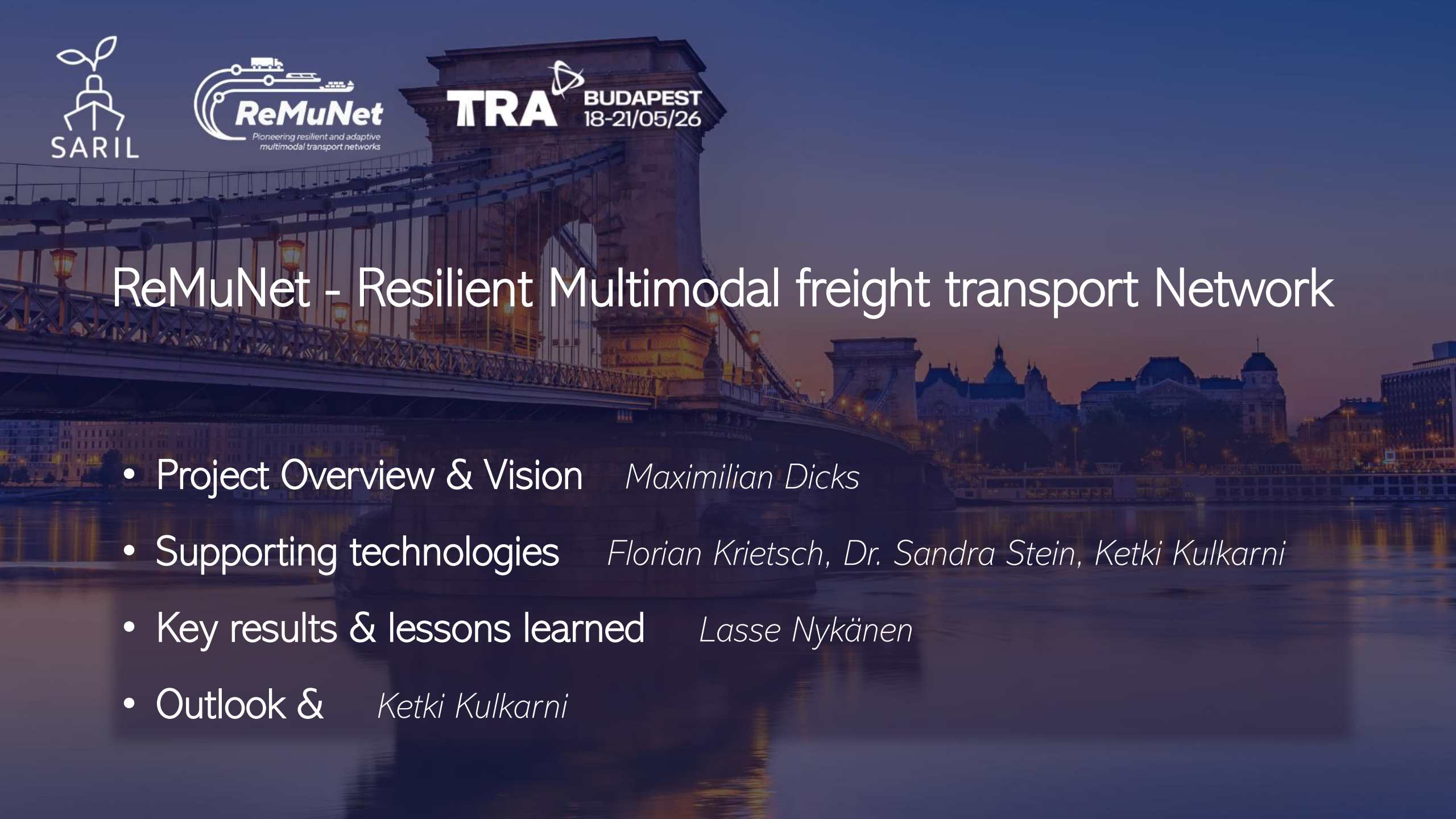
Sustainability And Resilience for Infrastructure and Logistics networks

- **Extends resilience definition to include sustainability – "green resilience":** minimise resources to withstand and recover from disruptions
- Directly **addresses resilience evaluation, KPIs, multi-stakeholder integration, green business models**
- Three geographic scenarios & disruption types: **regional** (Italy — floods + cyberattacks), **national** (Iberian Peninsula — climate hazards), **international** (N/C Europe — pandemics, war)
- **Stakeholder-driven:** Delphi surveys, three scenario workshops, foresight / backcasting sessions

Thank you

octavia.stepan@ec.europa.eu



ReMuNet - Resilient Multimodal freight transport Network

- Project Overview & Vision *Maximilian Dicks*
- Supporting technologies *Florian Krietsch, Dr. Sandra Stein, Ketki Kulkarni*
- Key results & lessons learned *Lasse Nykänen*
- Outlook & *Ketki Kulkarni*

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ReMuNet

Pioneering resilient and adaptive multimodal transport networks

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Project Overview & Vision

Maximilian Dicks (FIR/ReMuNet)

20/05/2026

PARTNERS

fir RWTH Aachen University

HANKEN

PTV GROUP

4PL Intermodal

MANSIO truck meets truck

Fraunhofer AUSTRIA

HAFEN WIEN

WHITE

Fraunhofer EMI

Universidade de Vigo

UIRR Union Internationale pour le Transport Combiné Rail-Route

CONTARGO trimodal network

vedia

DANISH RED CROSS

Ilmatieteen laitos Meteorologiska institutet Finnish Meteorological Institute

alice Alliance for Logistics Innovation through Collaboration in Europe

SCHACHINGER LOGISTIK

CSL

Universidade do Minho

POLITECNICO MILANO 1863

RINA

Rangel Logistics Solutions

Łukasiewicz Poznański Instytut Technologiczny

Puerto de Vigo Autoridad Portuaria de Vigo

MARLO

cemosa ingeniería y Control

SINTEF

AIPO

Gebrüder Weiss

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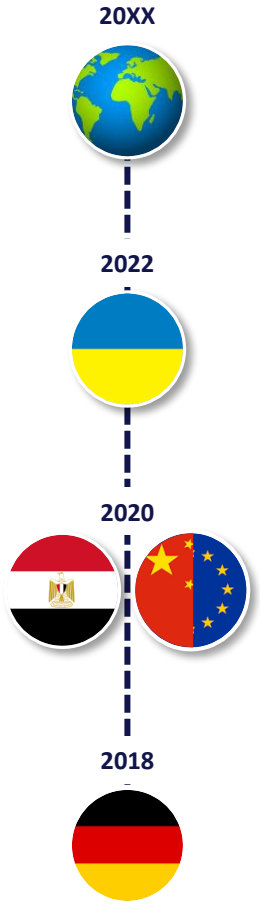
Supply chain disruptions have devastating effects on European economy



Potential Strait of Hormuz blockade could disrupt global supply chains, study finds

by Complexity Science Hub

edited by Lisa Lock, reviewed by Robert Egan · Editors' notes

The GIST

trans.INFO

German transport sector fears increased driver shortage due to war in Ukraine

You can read this article in 2 minutes

EDITORS' PICK

New China Lockdowns And Ukraine Conflict Bring Another Wave Of Supply Chain Issues

Pamela N. Danziger Senior Contributor

I study the world's most powerful consumers — The American Affluent

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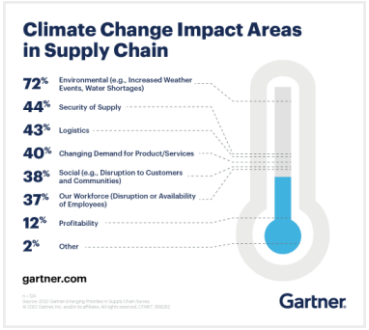


MARKETS

The ship that blocked the Suez Canal may be free, but experts warn the supply chain impact could last months

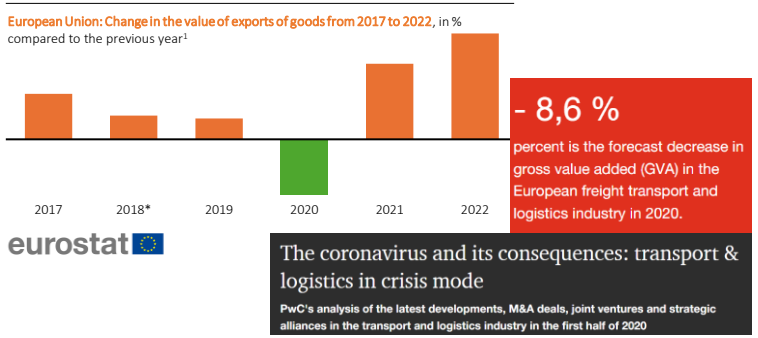
CNBC

Analysis

How the Suez canal blockage can seriously dent world trade

Gwyn Topham

The Guardian



Supply chains need to become more resilient!

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The ReMuNet consortium

Resilient Multimodal freight Transport Network

Completion Jun 2026

Mid-term Dec 2024

Kick-off Jul 2023

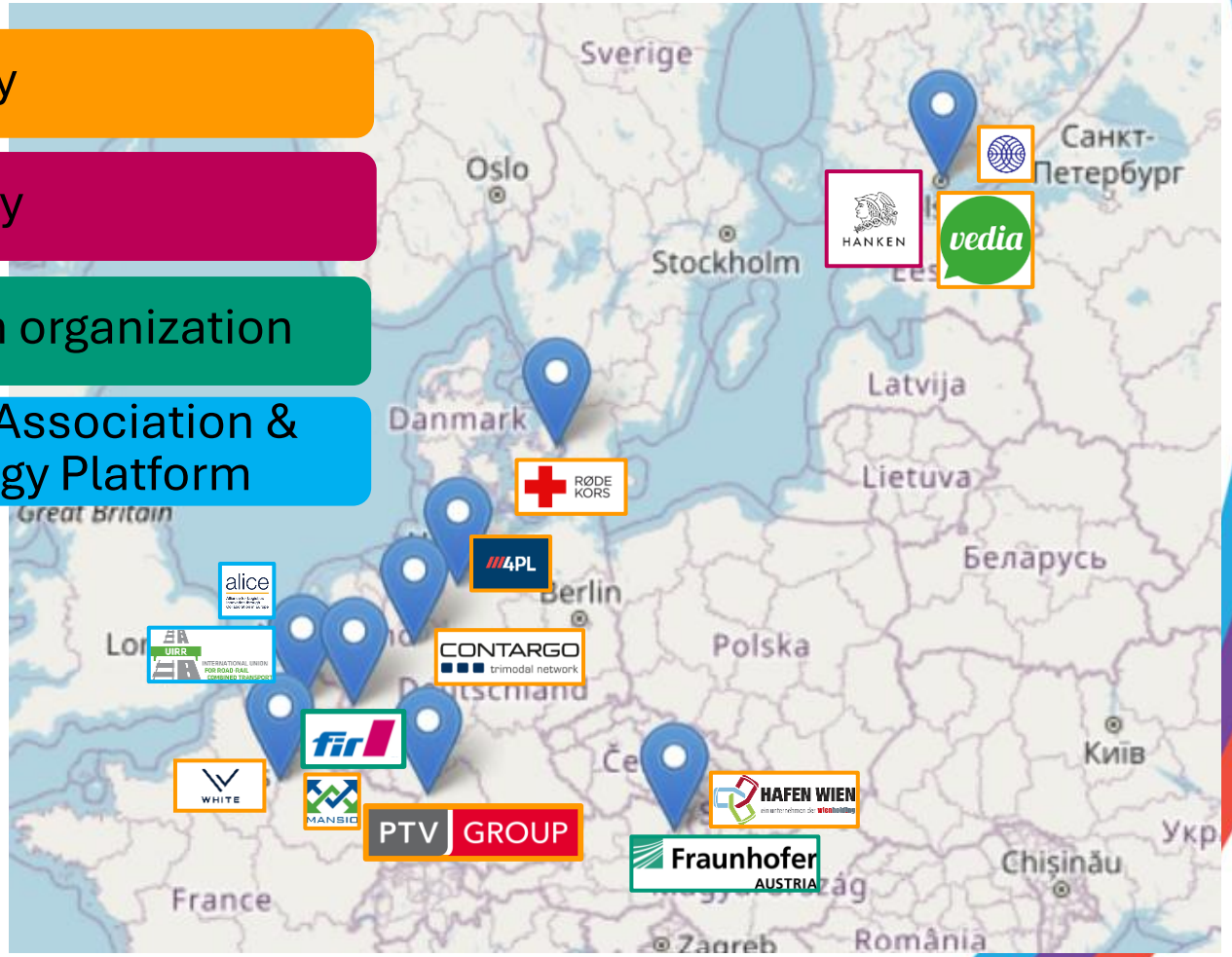
- Research & Innovation Action
- Grant agreement ID: 101104072
- Total budget: 3.99 MEuro

Company

University

Research organization

Industry Association & Technology Platform



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Pioneering resilient and adaptive multimodal transport networks

ReMuNet aims to increase resilience and sustainability of European freight transport

Intermodal & International

- Road
- Rail
- Inland Waterways

Project Volume: 4 Mio. €

Duration: 07/23-06/26

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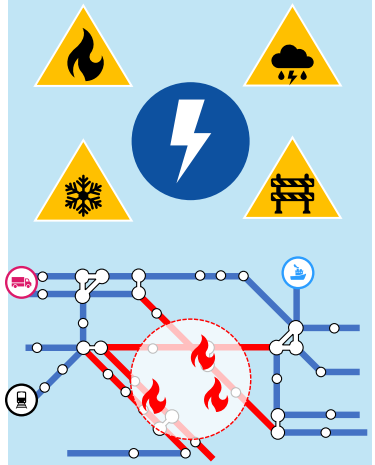
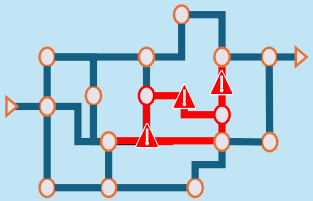
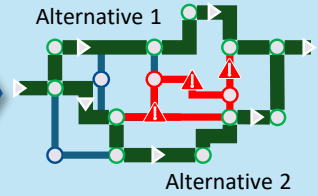
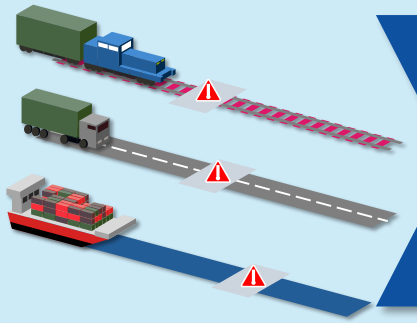
Understand disruptions and their impact



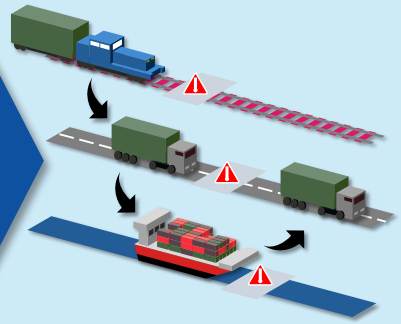


Identify alternative routes





Orchestrate freight transports on a digital platform to bypass disruptions and increase resilience



fir an der RWTH Aachen
WHITE
MANSIO truck meets truck
CONTARGO® trimodal network
VDV Die Verkehrsunternehmen
SGKV
HAFEN WIEN ein unternehmen der wienholding
4FLOW Your supply chain solution
Fraunhofer AUSTRIA
HANKEN
4PL Intermodal
PTV GROUP
UIRR
vedia
UNION INTERNATIONALE POUR LE TRANSPORT COMBINE RAIL-ROUTE
INFORM
SCHACHINGER LOGISTIK
alice Alliance for Logistics Innovation through Collaboration in Europe
FMI
RØDE KORS
CargoBeamer®
Kouvola Innovation
TRANSPOREON transforming transportation
Huoltovarmuuskeskus
Försörjningsberedskapscentralen
National Emergency Supply Agency

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ReMuNet pursues a multi-stage approach to increase multimodal freight transport resilience

Understanding
of multimodal transport networks and description of the effects of disruptive events

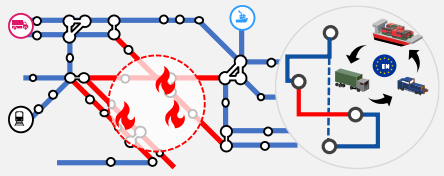
Calculation
of multimodal transport route options in the face of disruptive events

Enabling
of collaborative synchromodal freight transport

Piloting & Improvement
system-optimising transport and route allocation

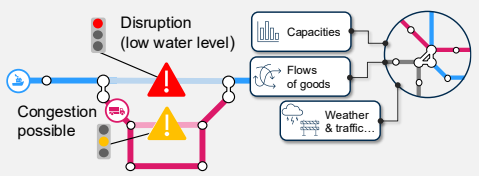
European transport networks

WP 1
Developing European multimodal transport ontology & classifying disruptive events and their impact on transport networks



Reference Model & Algorithm

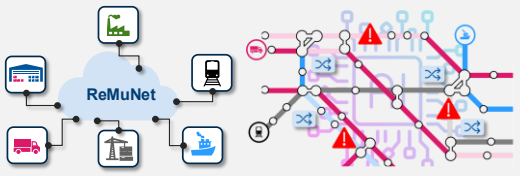
WP 2
Creating reference infrastructure network and routing algorithm focusing on European multimodal transport corridors



Platform Development & Application

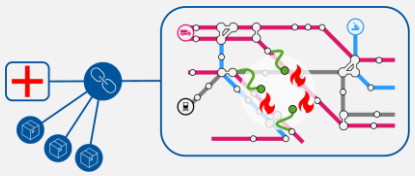
WP 3
Designing collaborative platform with high operational interconnectivity for event-based synchromodal relay transport

WP 4
Modelling self-learning transport corridors to increase resilience and reduce emissions



WP 5
Piloting event-based multimodal relay transport in North Sea - Baltic and Rhine - Danube corridors

WP 6
Dissemination and joint activities



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Project dissemination & Online Presence

ReMuNet
Pioneering resilient and adaptive multimodal transport networks

Website | Newsletter & Webinars | Social media | Publications | Events & Collaborations

10 Established **collaborations** with other EU projects

ESEP 4Freight, DISC, eFTI4EU, SUM, SARIL, unchain, GEMINI, ADMIRAL

11 project-related **scientific publications**

11 joined **conferences** in different countries

>600 **Followers** on social media

LinkedIn, X, Facebook, YouTube

Scan me to visit the **ReMuNet Website**

Scan me for **introduction video**

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Software solutions along the cycle

Florian Krietsch (PTV/ReMunet)

20/05/2026

PARTNERS

RWTH Aachen University, HANKEN, PTV GROUP, 4PL Intermodal, MANSIO truck meets truck, Fraunhofer AUSTRIA, HAFEN WIEN, WHITE, Fraunhofer EMI, Universidade de Vigo, UIRR Union Internationale pour le Transport Combiné Rail-Route, CONTARGO trimodal network, vedia, Danish Red Cross, Ilmatieteen Laitos Meteorologiska Institutet Finnish Meteorological Institute, alice Alliance for Logistics Innovation through Collaboration in Europe, SCHACHINGER LOGISTIK, CSL, Universidade do Minho, Politecnico Milano 1863, RINA, Rangel Logistics Solutions, Łukasiewicz Poznański Instytut Technologiczny, Puerto de Vigo Autoridad Portuaria de Vigo, MARLO, cemosa ingeniería y Control, SINTEF, AIPO, Gebrüder Weiss

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Algorithms and services for two key questions

Level	Time Horizon	Key Question
Strategic	Weeks – Months	How do I design and plan the network optimally?
Dynamic / Operational	Minutes – Hours	How do I respond to disruptions in real time?

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Strategic Level | **Dynamic Level**

Before starting the transport process

Short-term receipt of information about disruption

During the transport process

Disruption

Strategic phase

Strategic basis for tactical planning in the event of a disruption

Algorithms
scenarios
Plans

Tactical phase

Short-term plans → What options are available to respond to disruption?

Optimization through required:
- Capacities
- Prices

Options:

a. **Booking Alternatives**
(Shift Mode/ Not)

b. **Distribution of Risk**
1b. Operational capacity (Transports)
2b. Infrastructure (Warehouses)

c. **Cooperation**
required:
1c. Visibility (capacities)
2c. Strategic agreement

Cluster manager → Crisis manager

Sovereignty rights:
✓ Limiting capacities
✓ Redistribute / allocate

Who becomes sovereign and when, and what rights do they have?

Operative phase

Transfer to alternative routes

Operational implementation of relay traffic:

Wait
Or
Replacement

End customer

Possible reaction:
Production shutdown

Derivation of a learning process

System Recovery

Goal:
Self-learning System

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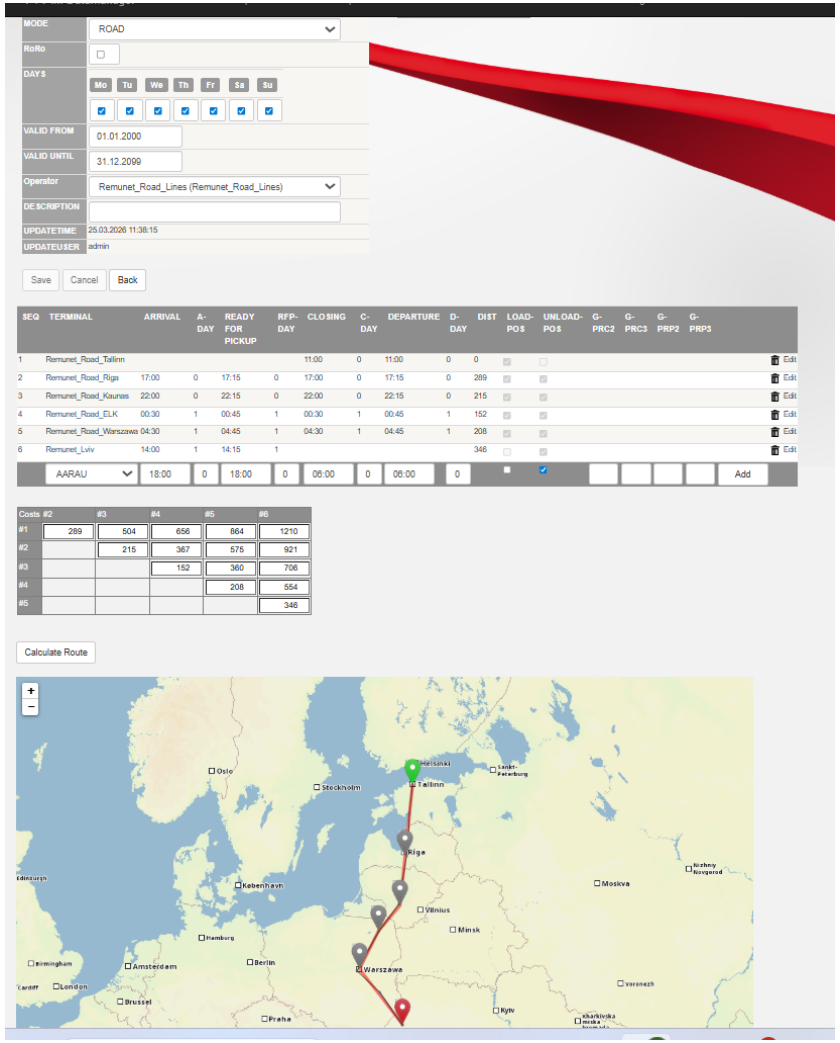
Enabler: Harmonised data model for spanning the (intermodal) service networks.

Data Source	Type	Nodes	Transport route section	Disruptive events	Mode of transport
C-roads	Closed API			X	Road
Marine traffic	Open API			X	Ship
Rail Cargo Austria	Closed API			X	Rail
ÖBB	Open API			X	Rail
Qgis	Open API			X	Road, Rail
Ten-T / Ten-Tech	Closed API			X	Road, Rail, Ship
Euris	Open API				Ship
BAW	Closed API				Ship
SGKV	Closed API		X	X	Road, Rail, Ship
TX Logistics	Open API			X	Road, Rail
Mobilithek	Open API			X	Road, Rail, Ship
Asfinag	Open API	X	X		Road
Datex II	Open API	X			Road
Route Scanner	Open API			X	Road, Rail, Ship
Contargo	Open API			X	Road, Rail, Ship
Trassenfinder	Open API				Rail



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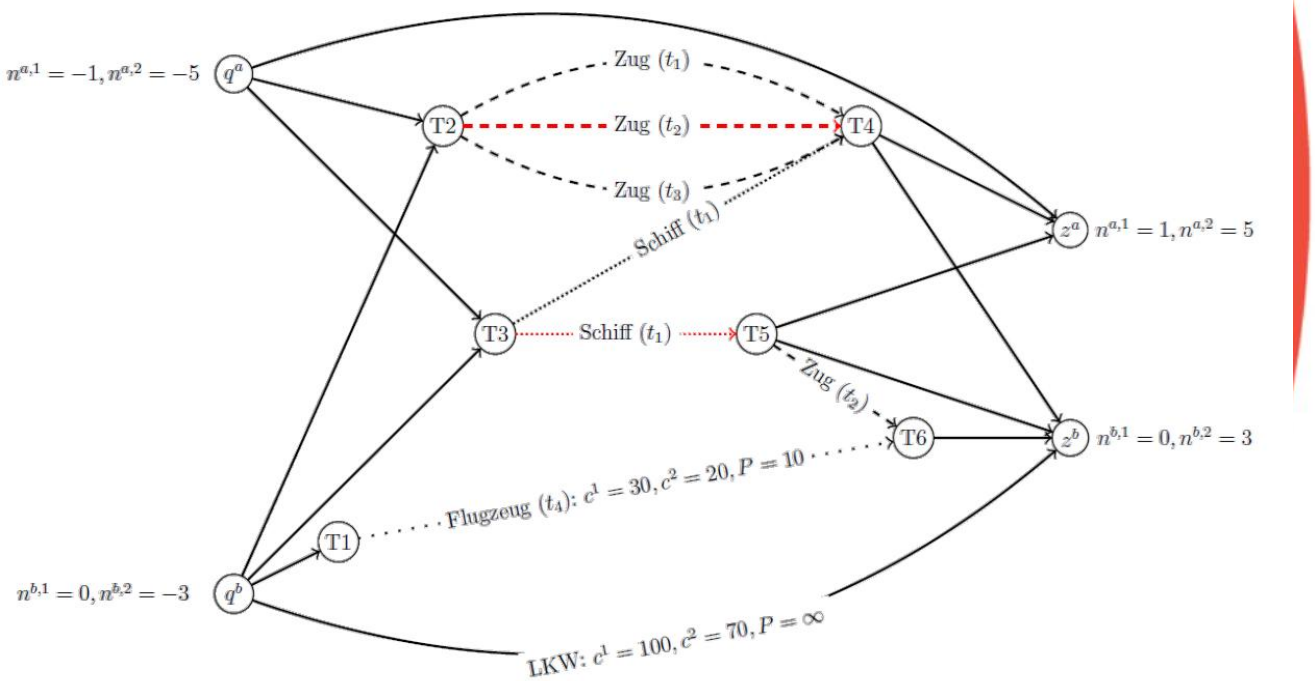
Strategic level

Intermodal Routing

- Method: Routing on multimodal graphs with time-dependent edge weights (cost, time, CO_2)



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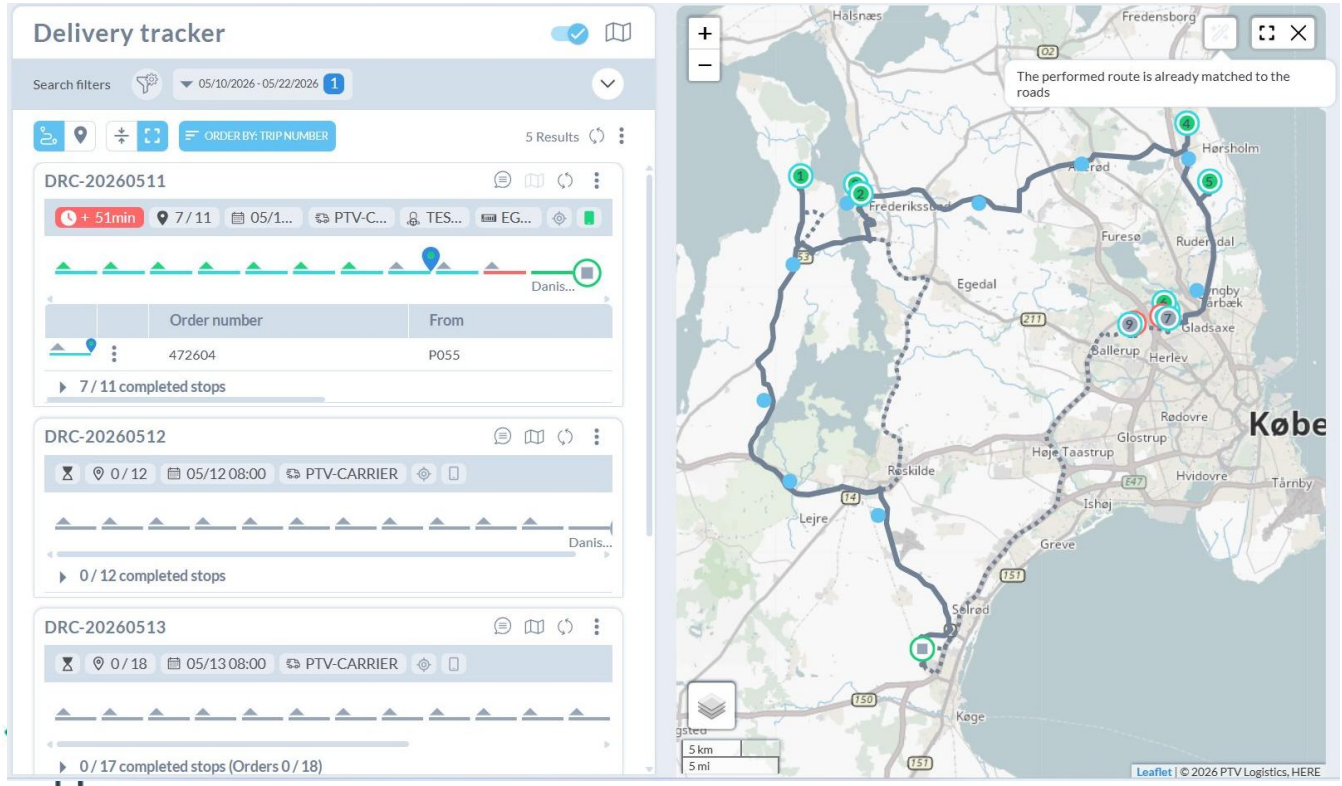
Operational Level
Real-time Rerouting, Truck visibility and dispatching

Truck driver can report during execution disruptions to back-office planner

Or

can change by himself the trip sequence and receive new route and guidance



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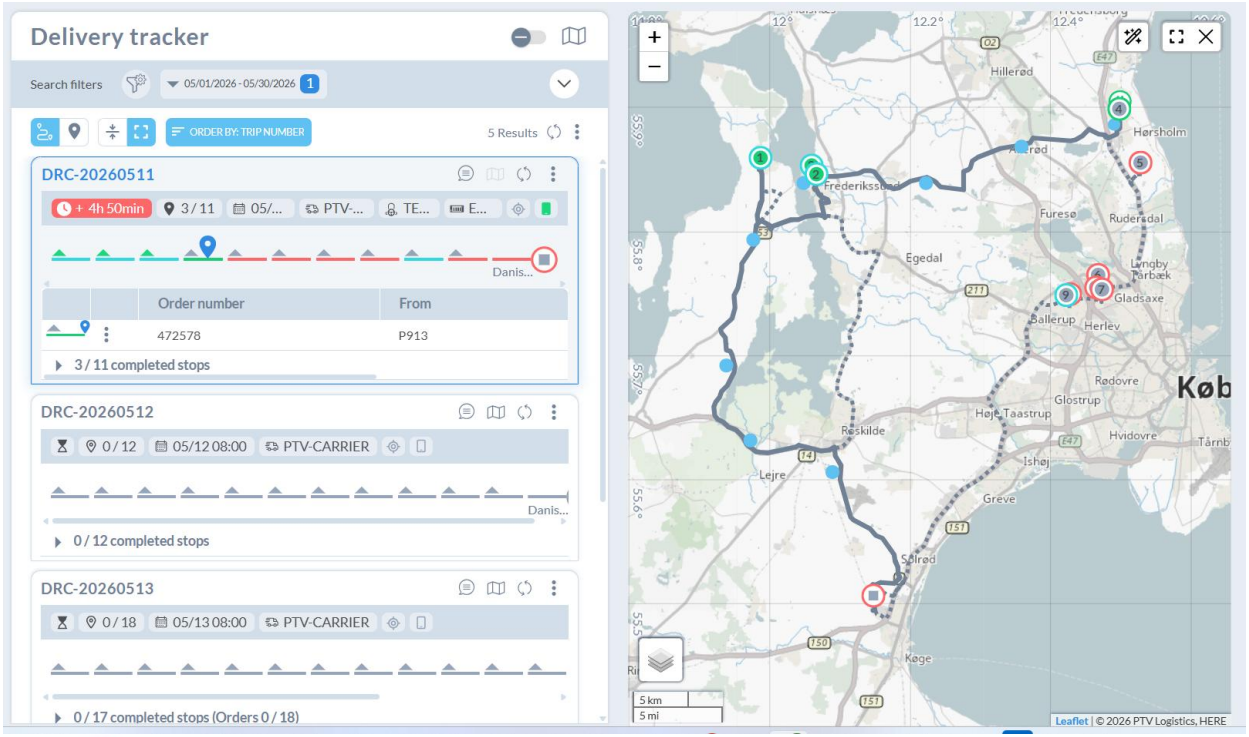
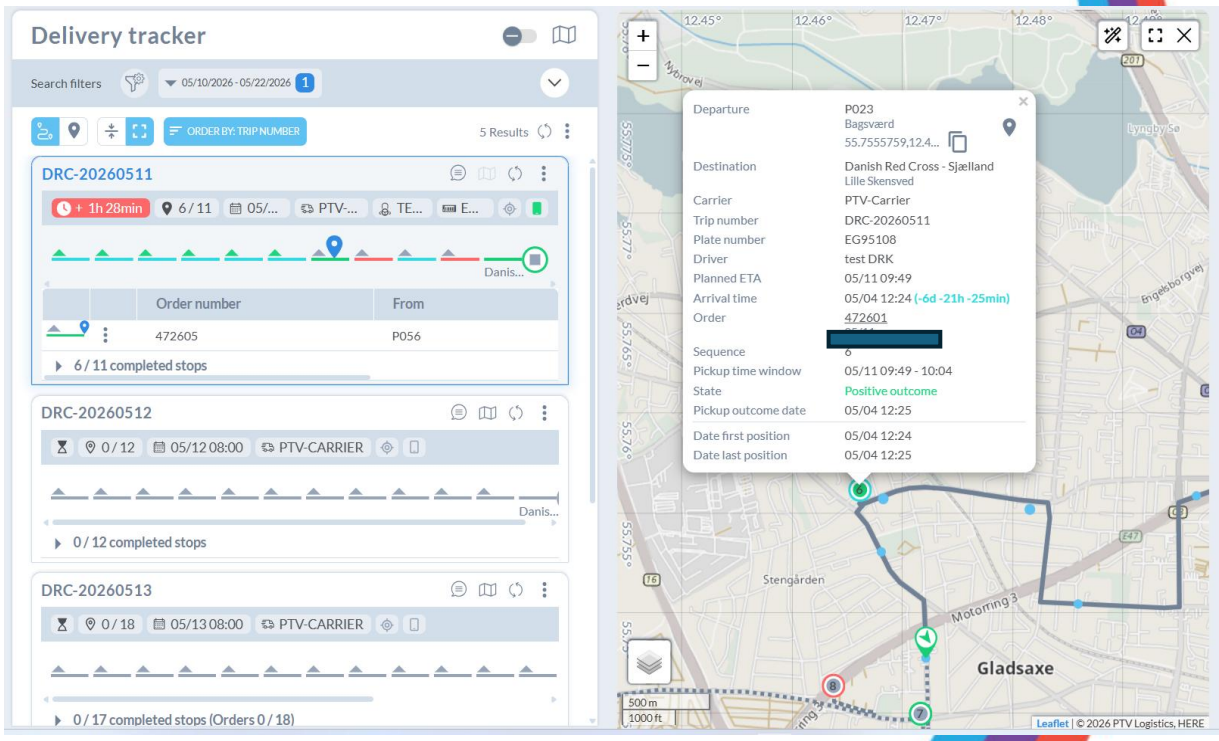
Operational Level
Real-time Rerouting, Truck visibility and dispatching

Healing over time by e.g. network healing and sequence optimization





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Disruption Scenario Simulation

- Application: Pre-assessment of network vulnerabilities — which nodes or links have the highest failure impact?
- Example: Simulation shows that a failure at an intermodal hub, e.g. Duisburg that affects 34% of Rhine–Danube volume → prioritisation of redundancy measures

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ReMuNet Platform

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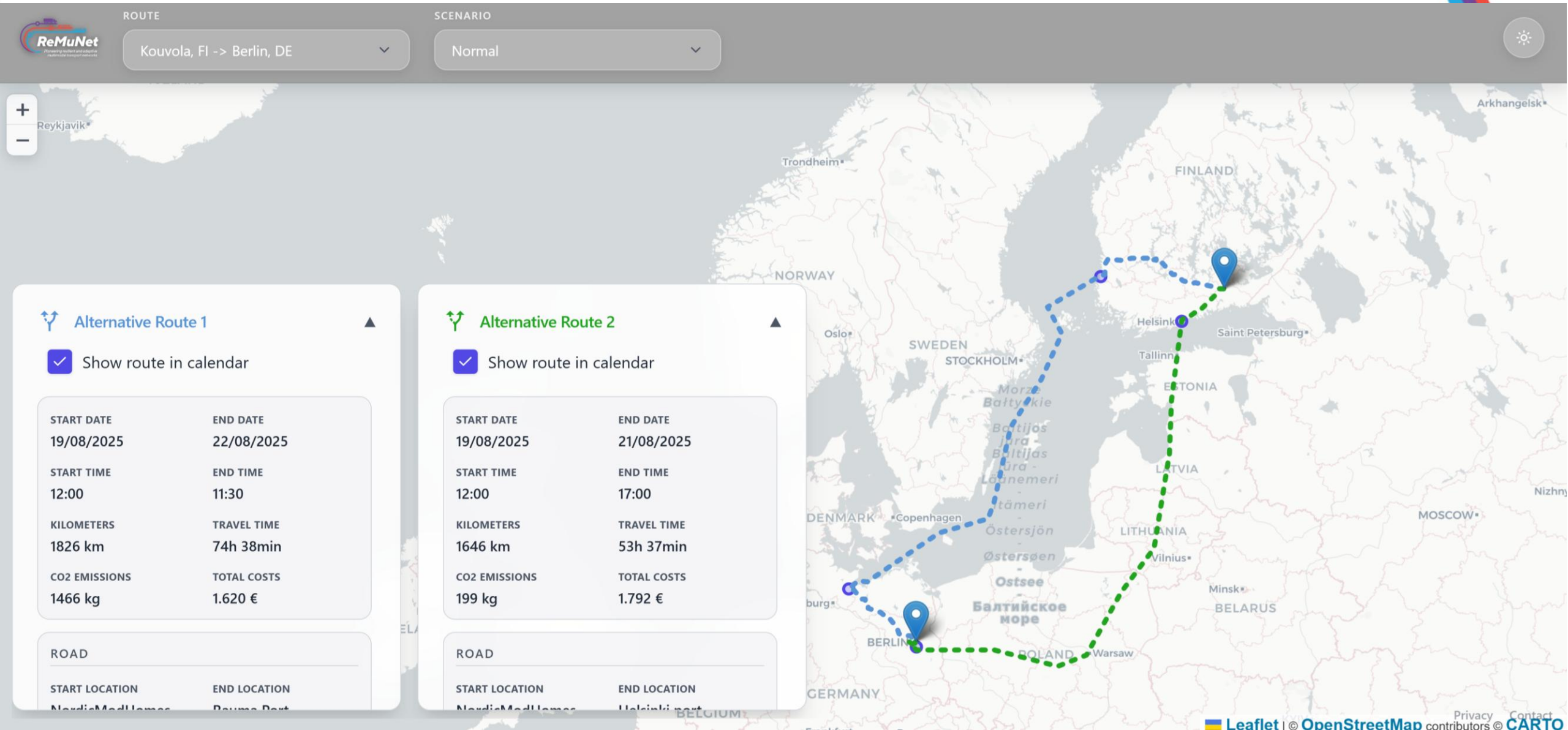
Pioneering resilient and adaptive multimodal transport networks

ROUTE: Kouvola, FI -> Berlin, DE

SCENARIO: Normal



Alternative Route 1

Show route in calendar

START DATE	END DATE
19/08/2025	22/08/2025
START TIME	END TIME
12:00	11:30
KILOMETERS	TRAVEL TIME
1826 km	74h 38min
CO2 EMISSIONS	TOTAL COSTS
1466 kg	1.620 €

ROAD

START LOCATION	END LOCATION
NordicMedHomes	Rauma Port

Alternative Route 2

Show route in calendar

START DATE	END DATE
19/08/2025	21/08/2025
START TIME	END TIME
12:00	17:00
KILOMETERS	TRAVEL TIME
1646 km	53h 37min
CO2 EMISSIONS	TOTAL COSTS
199 kg	1.792 €

ROAD

START LOCATION	END LOCATION
NordicMedHomes	Helsinki port

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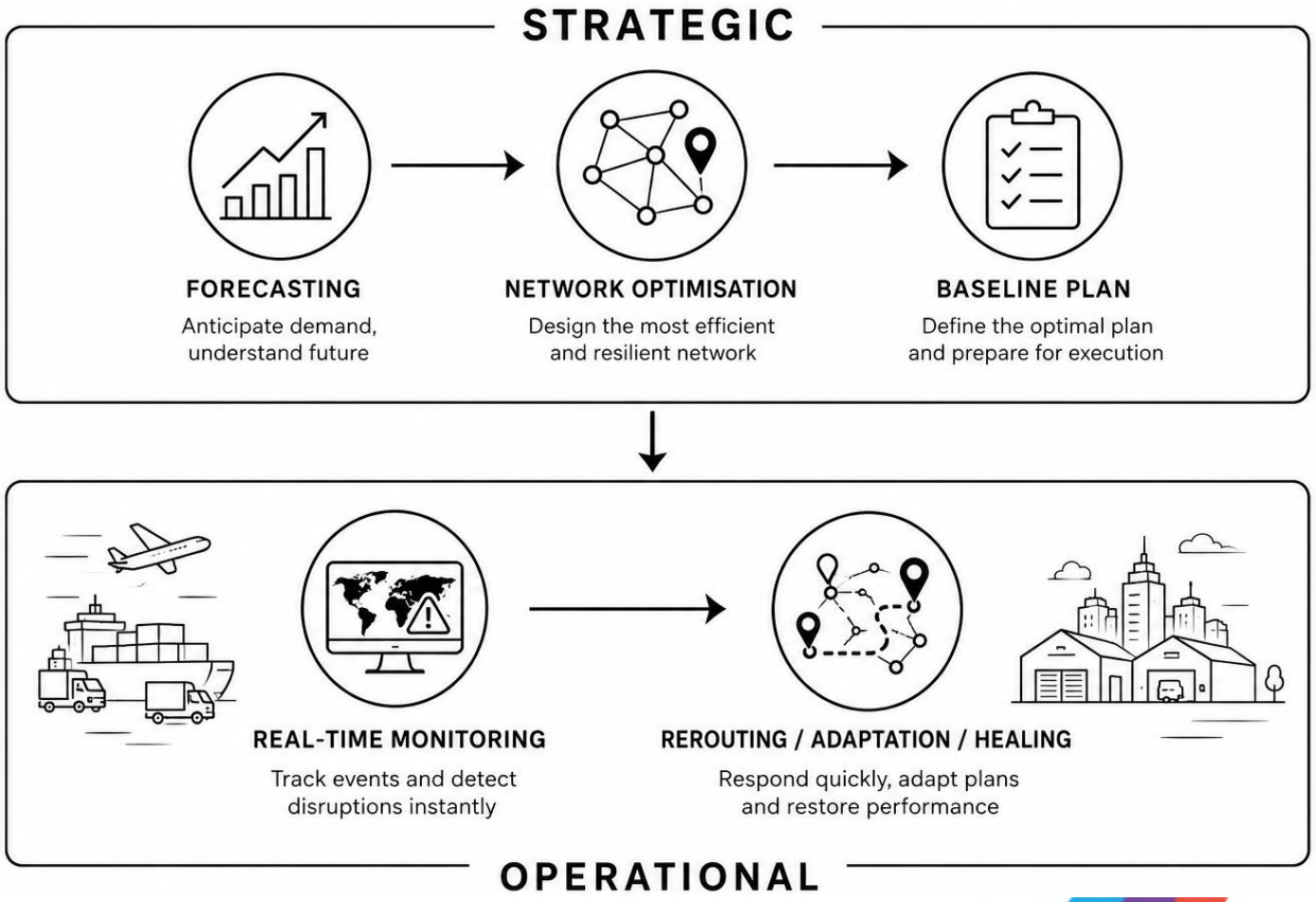
Tools along the chain

"The strategic level delivers the plan, the operational level keeps it alive"

"The key is that both levels share the same network model — this avoids inconsistencies and enables fast response when disruptions hit"



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Advanced and adaptive routing algorithms

Dr. Sandra Stein (FHA/ReMuNet)

20/05/2026

PARTNERS

RWTH Aachen University, HANKEN, PTV GROUP, 4PL Intermodal, MANSIO truck meets truck, Fraunhofer AUSTRIA, HAFEN WIEN, WHITE, Fraunhofer EMI, Universidade de Vigo, UIRR, CONTARGO trimodal network, vedia, DANISH RED CROSS, ILMATIETEEN LAITOS METEOROLOGISKA INSTITUTET FINNISH METEOROLOGICAL INSTITUTE, alice, SCHACHINGER LOGISTIK, CSL, Universidade do Minho, POLITECNICO MILANO 1863, RINA, Rangel LOGISTICS SOLUTIONS, Łukasiewicz Poznański Instytut Technologiczny, Puerto de Vigo, MARLO, cemosa ingeniería y Control, SINTEF, AIPO, Gebrüder Weiss

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Advanced routing algorithms

- The Synchromodal Transport Re-Planning Problem (STP) addresses real-time decision making in stochastic logistics networks.
- **Dynamic Environment:** Online re-routing triggered by real-time disruptions (delays, carrier failure).
- **Graph Topology:** Multimodal network (Road, Rail, Water) modeled as a directed multigraph.
- **Core Objectives:** Balancing transport costs, CO2 emissions, and delivery reliability.
- **Resilience focus:** Maintaining performance and enabling fast recovery after disruptive events.

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Hybrid-RL Methodology

	PPO Algorithm	Strategic Hyper-Heuristics	Reward Logic
Idea	▪ Uses Proximal Policy Optimization to train a high-level agent that acts as a strategic decision-maker across the network.	▪ Instead of manual routing, the agent selects from pre-defined paths: ▪ Cheapest ▪ Earliest Arrival ▪ Low CO2	▪ Optimized via a multi-objective function that prioritizes rail/water modes and strictly penalizes delivery tardiness.
Impact	▪ Delivers stable, real-time policy convergence. The trained agent navigates sudden network disruptions by adapting the overall network strategy rather than recalculating from scratch.	▪ Reduces computational overhead. The system learns to "pivot" between priorities—such as selecting "Fastest Route" only when a deadline is threatened or "Lowest CO2" when temporal slack allows.	▪ Aligns the algorithm's choices with real-world KPIs. By penalizing delivery tardiness while rewarding on-time arrivals, the policy successfully shifts freight loads to rail and water without violating critical customer deadlines.

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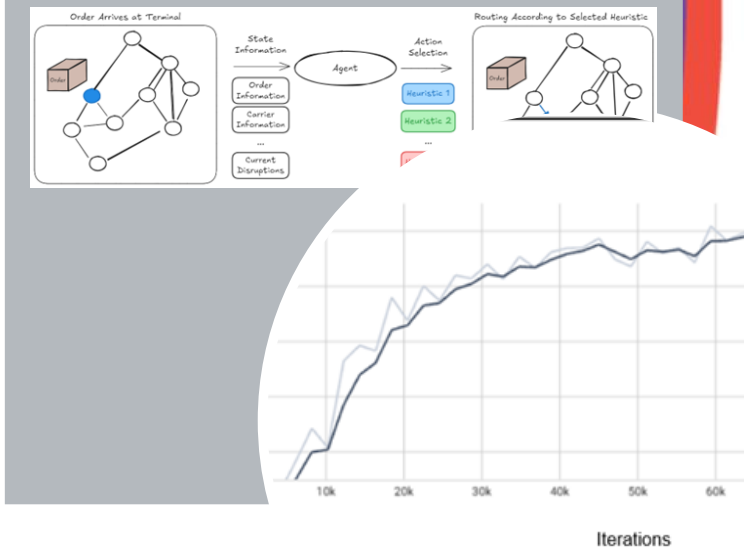
Results

The framework was validated on the Rhine-Danube corridor, demonstrating policy convergence and adaptive routing.

- Performance: Successfully shifted load to rail when deadlines allowed, reducing CO2 impact.
- Status: Achieved TRL 4 (Functional Proof-of-Concept) for synchromodal re-planning
- Future Research: Evolving the prototype into a scalable architecture capable of handling complex, real-world networks.

- **Tested in different scenarios, the RL agent demonstrated that it learns a stable policy that orchestrates the network's recovery - saving time and reducing environmental impact.**

The solution showes that sustainability does not have to come at the cost of reliability.



Technology readiness level *4*
Implementation stage :
Pilot

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Modelling Risk Intelligence: A proof of concept

Ketki Kulkarni (HAN/ReMuNet)

20/05/2026

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Modelling Risk Intelligence: A Proof of Concept

1 · BUILD THE DATA

Systematic disruption data collection

- **110 verified events,** 2018–2025
- Sources: national news agencies, port & rail authorities, logistics press, humanitarian cluster reports
- 4 event types: drought, flood, strike, accident
- **Extended for Baltic–Ukraine corridor:** border disruption events — protest blockades, crossing closures (2022–2025)
- 87 locations across European freight network

→ Unified disruption dataset

2 · MODEL THE RISK

Statistical risk modelling

- Disruption rates per location × event type × mode
- **Poisson probability model —** likelihood of disruption in any given time window
- Seasonal adjustment via monthly multipliers (e.g. August = 3× drought risk on Rhine)
- **6 geographic regions** for robust pattern aggregation — incl. Baltic–Ukraine Corridor as a distinct region
- Impact mapping: event type → capacity loss & duration

→ Seasonally-adjusted risk rates

3 · RISK CALCULATOR

Interactive dashboard & scenario player

- Node-level lookup: location, mode, month → risk level + disruption probability
- **Route-level scenario player:** leg-by-leg risk table + composite route probability
- Disruption trigger → side-by-side rerouting comparison
- Month slider — seasonal recalculation across full route
- **Demonstrated on 2 humanitarian scenarios:** Helsinki → Dnipro & Berlin → Dnipro

→ LOW / MODERATE / HIGH / CRITICAL

110 events | **87** locations | **6** regions | **5** disruption types | **2** humanitarian scenarios

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Key results & lessons learned

Lasse Nykänen (VED/ReMuNet)

20/05/2026

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Piloting and validation

- WP5 - Piloting event-based synchromodal relay transport in North Sea – Baltic and Rhine – Danube corridors
  - Objectives: To test and validate ontologies, approaches, and algorithms, successful PoC of ReMuNet platform and synchromodal relay transport.

What would they do? What they need?

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ReMuNet approach

Three use cases:

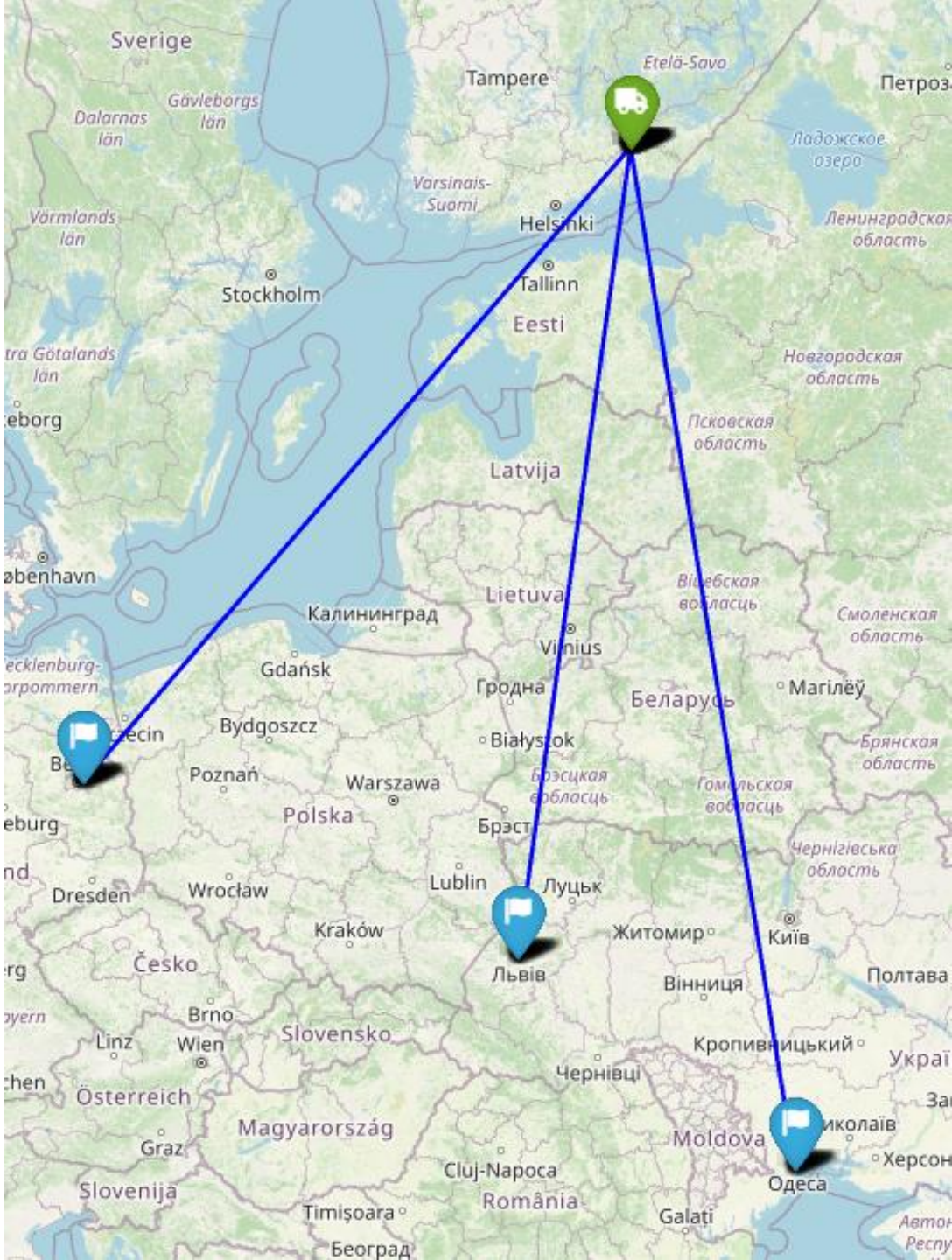
- North Sea – Baltic corridor
- Rhine – Danube corridor
- Humanitarian use case

Several disruptive event scenarios:

- What if thinking?
- Potential disruptive events
- Hypothesis for re-routing

Realistic, but simulated transport data

- Real world multimodal and international transportation chains



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Key results

- System architecture and POC for synchromodal platform available
  - Integrations of sub-systems, timetables and routing solutions
  - Integrations of use cases
- Disruptive data space
  - Real world demand
  - Scientific background
  - Big opportunity for future innovations
- Real world piloting
  - Driver app - AXYLOG
- First draft of ReMuNet platform and concept
  - Further development needed
  - Opportunities and business potential recognized

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Lessons learned

- Technical problems can be solved
- Synchromodal platform needs close collaboration with service providers
  - Timetable information gives good information, but booking details and contractual features would be the game changer
- National and local implementations are not enough for industry
  - Regional or even EU-wide coverage needed
- Piloting and POCs are good way to test theory
  - Fail fast & learn quick approach

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What next

- Under ReMuNet project we will summarize and document our pilots, findings and recommendations
- After the project we see great opportunities to further develop the POC
  - More region or corridor driven implementation
  - Disruptive dataspace development and engagement of transport and traffic management authorities
- Business model and use case development

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Outlook: future research directions and exploitation potential

Ketki Kulkarni (HAN/ReMuNet)

20/05/2026

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Outlook: What makes ReMuNet different?

Multimodal routing platforms are **not new.**

→

Disruption-aware routing
— intelligence built in, not bolted on

Deep-dive into disruptions

Went beyond event lists — built a structured ontology, root-cause analysis, and social impact typology to understand disruptions as a system.

Bridging the gap

Translated stakeholder knowledge and qualitative insights into usable quantitative tools — moving from how experts talk about disruptions to how algorithms can act on them.

Risk intelligence — proof of concept

Built a disruption events module and risk calculator on real historical data. Next step: full integration into routing logic for operational and strategic use cases.

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Future Research Directions

01

Risk-intelligent routing

The disruption module is a proof of concept. Fully integrating probabilistic risk intelligence for routing and network decision support — so recommendations optimise across cost, time, and disruption likelihood — is the critical next step.

02

Extreme use cases as platform design drivers

Involving actual end-users in design surfaced requirements that routine freight never would. Humanitarian logistics revealed dynamic network topologies (nodes disappearing in real time); the ecological pilot raised hard modal-choice constraints under emissions limits. Designing for the extreme is a methodology that should continue — other candidates include cold-chain logistics under disruption.

03

Scaling, adoption, and the human layer

Algorithms can reroute in seconds based on a common data set. Getting dispatchers, forwarders, and SMEs to trust and act on those suggestions is a different research problem — one requiring work on explainability, decision-support interfaces, and low-barrier onboarding.

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Exploitation Potential

Commercial & Platform

Routing algorithm (PTV & MAN)

Commercial exploitation via integration into existing products; powered-by attribution model.

ReMuNet platform + Fit4ReMuNet tool (FIR)

Path to continued development beyond the project; sustainable business models already scoped. Onboarding and training for industrial stakeholders (Fit4ReMuNet)

Data pool & simulation environment (CON, MAN, PTV)

API-based access model; hosted by platform operators, enabling scale-up to new corridors.

Open & Research

Disruption ontology & typology

Open source, free to use. Foundation for European interoperability standards and future Horizon projects.

Risk assessment framework & stress-testing methodology

Reusable tools for any platform operator extending to new corridors — including post-conflict reconstruction in Ukraine.

Crisis-to-platform feature mapping

Structured evidence-base for designing next-generation routing platforms for extreme operating environments.

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Resilience isn't a feature you add

It's something you design for under pressure.

Foundation built

Platform, tools, ontology, datasets

Integration next

Risk intelligence fully embedded in routing

Stress-tested

From war zones to green corridors

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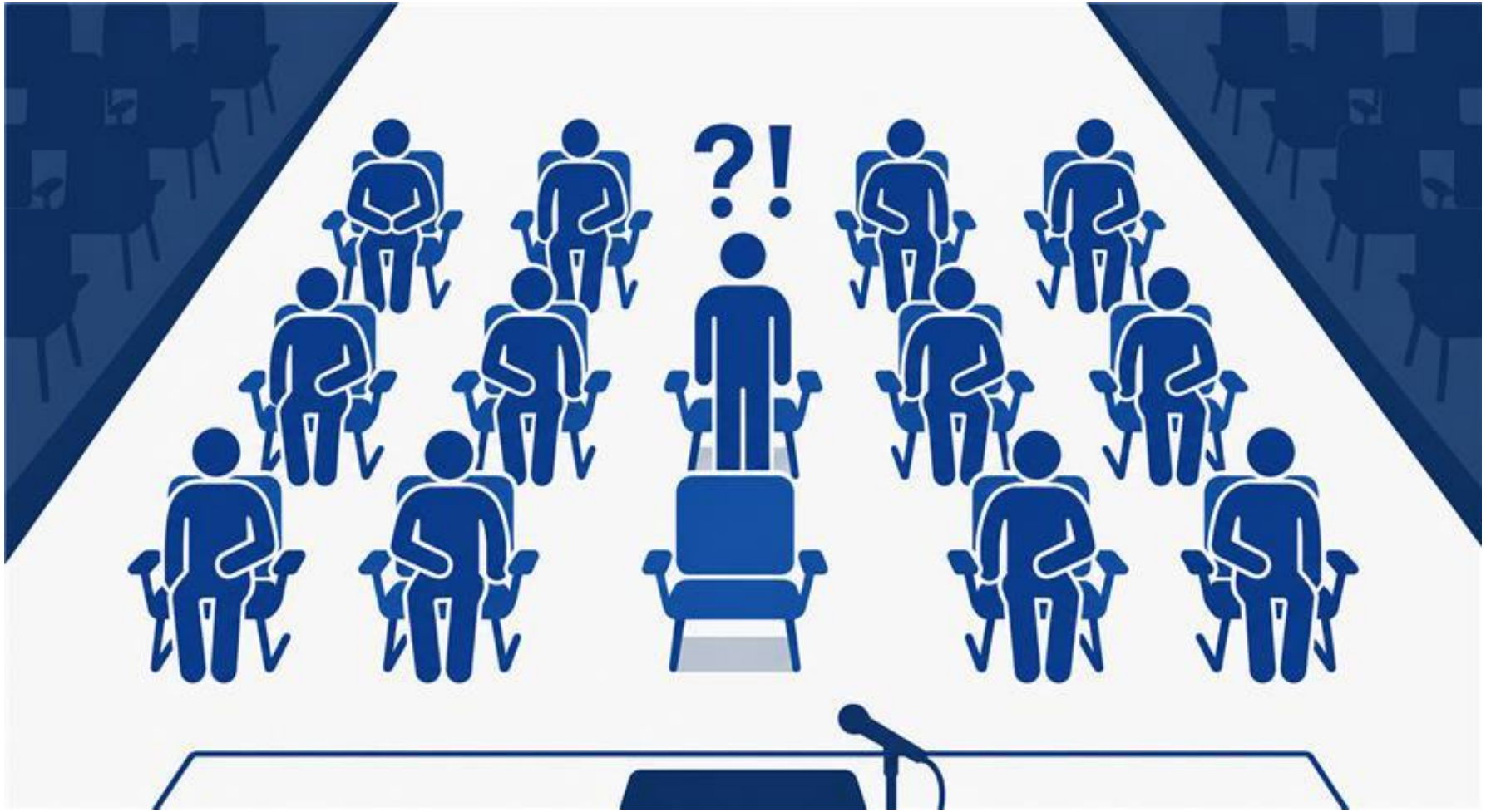
Do you have any questions?



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TRA BUDAPEST 18-21/05/26

SARIL - Sustainability And Resilience for Infrastructure and Logistics networks

- Project Overview *Kris Schroven*
- SARIL Tool-Kit *Paula Lopez Arevalo*
- Business Models and Strategic Recommendations *Marta Waldmann*
- Stakeholder Perspective *Diana Noriega & Mariusz Graca*

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SARIL - Project overview

Kris Schroven (SARIL)

20/05/2026

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The SARIL consortium

Together for sustainable resilience in logistics

Completion May 2026

Mid-term Nov 2024

Kick-off June 2023

- Research & Innovation Action
- Grant agreement ID: 101103978
- Total budget: 3.98 MEuro

Company

University

Research organization

European Technology Platform

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SARIL Vision

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SARIL Vision

How to make freight transport more resilient?

Can disruptions be handled in a sustainable way?

Give decision support

- Disruption handling
- Sustainable solutions in resilience concepts
- Investments that increase resilience

Give recommendations

- Business models
- Regulatory measures

for transport and logistics systems.

On different scales.

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A system is resilient and sustainable, if it uses minimal resources to withstand and recover from disruptions

Stakeholder Engagement

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Stakeholder Engagement

Ensures relevant project output

1. Interviews and surveys:
Topics: disruptions, disruption handling

2. Two rounds of workshops:
Topics: Future images, Sustainability and joint platform

- Takeaways:

Identification of three stakeholder roles

R1
Develop and maintain transport infrastructure

R2
Configure transport and logistics networks

R3
Manage transport and logistics operations

Technical solutions of the project need to be integratable into transport management systems in use.

Sustainability is only/mainly considered in ‚good weather conditions.

Clear call for interoperable, user-friendly tools, combining real-time operations and planning analytics

Data sharing and availability is key for disruption handling.

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SARIL Scenarios

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The three SARIL scenarios

Basis for the sustainable resilience analysis

Regional scenario
- Small-scale
- Flooding + data unavailability

National scenario
- Medium-scale
- Wildfires

European scenario
- Large-scale
- Pandemic and War

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SARIL Project Structure

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Project structure

Stakeholder engagement

Scenarios

SARIL toolkit

Green resilience assessment

Impact & Demonstration

Recommendations

Green Resilience Methodology

- Part 1 Vulnerability and Risk Assessment
- Part 2 Transport and Traffic Modelling
- Part 3 Resilience Assessment
- Part 4 Sustainability Aspects

Data Management

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SARIL Toolkit: functionalities and applications

Paula Lopez Arevalo (SARIL)

20/05/2026

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SARIL Tool Architecture

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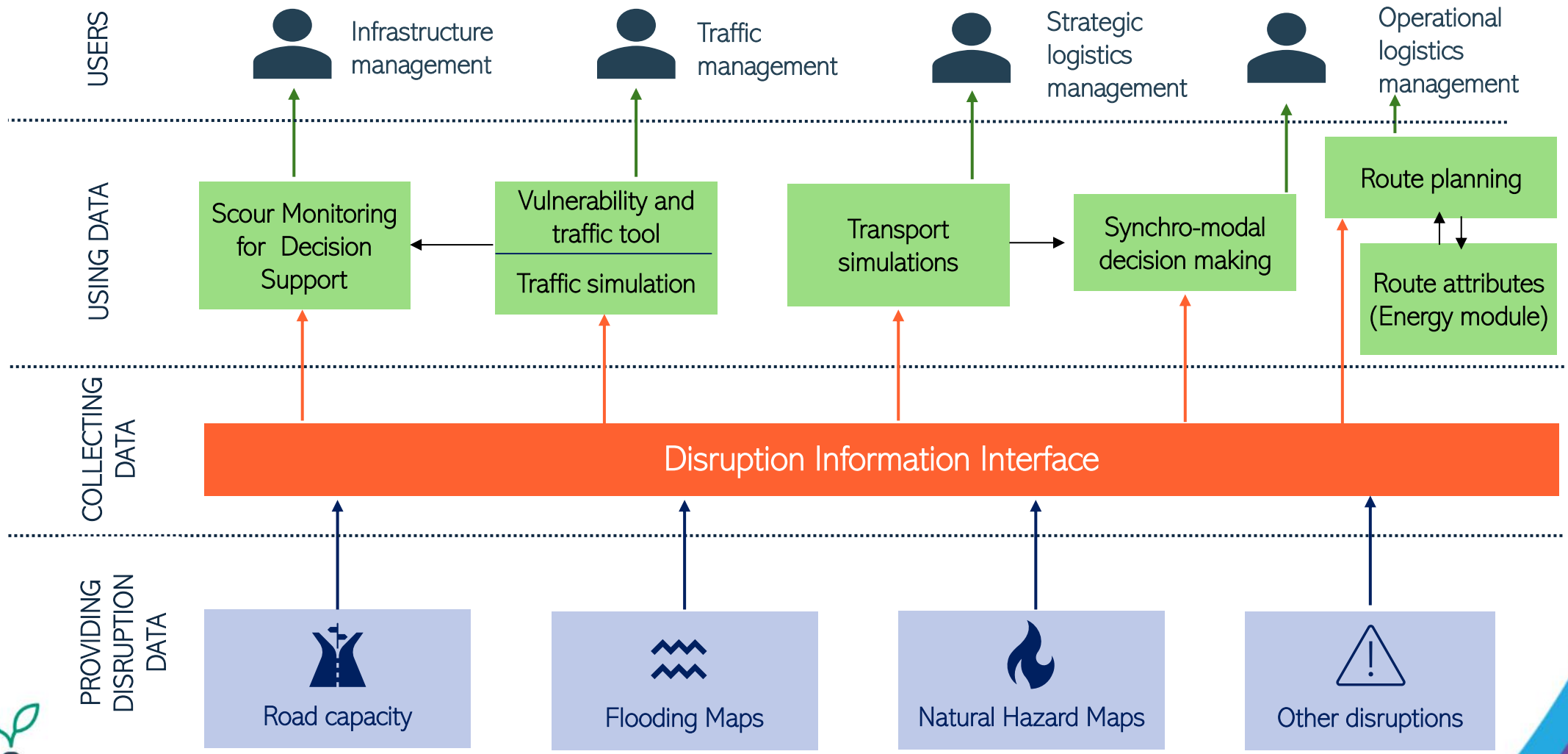
SARIL Tool Architecture



SARIL Tools Description

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Natural Hazard Map Tool

Universidade Vigo

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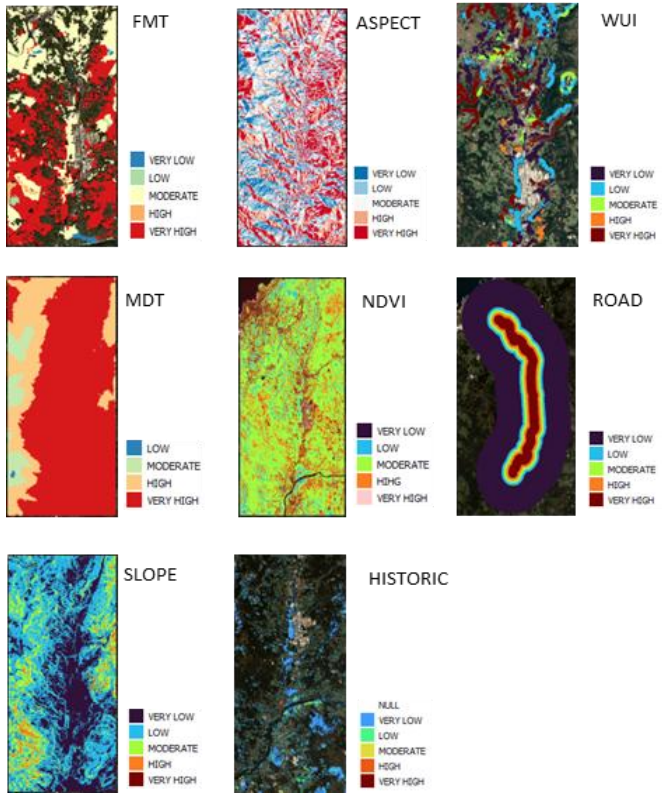
- Forest fire risk prediction
- Ignition point on a map
- Simulate wildfire propagation
- Other weather alerts (rain & wind)

I. **Motorway A55 Spain (Vigo-Tui)**

The Vigo-Portuguese border motorway or A-55 is a Spanish motorway including in Atlantic corridor infrastructure which currently links the towns of Vigo and Tuy in Pontevedra and continues to the Portuguese border where it connects with the A3 (Autoestrada Entre-Douro-e-Minho).

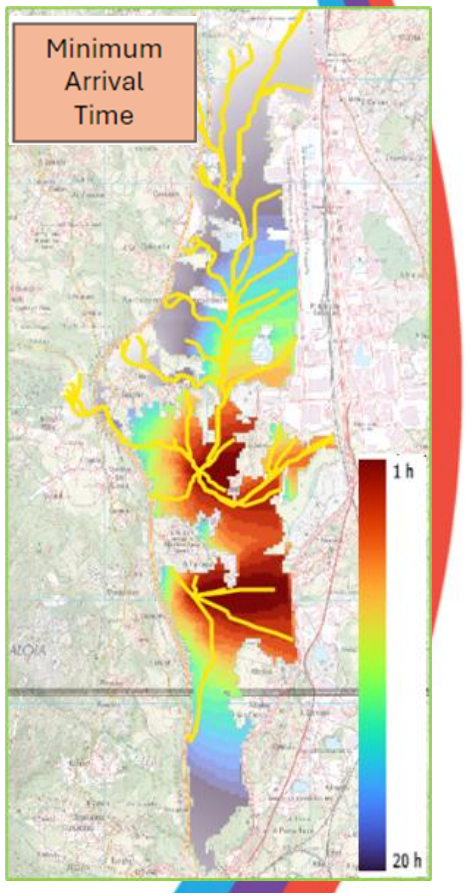
Figure 28. Motorway A55. a) Iberian Peninsula map area and A55 Motorway location, b) A55 motorway Vigo - Tui, c) A55 motorway picture.

A55 Motorway



Tool layers

Risk Map



Propagation Map

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Natural Hazard Map Tool

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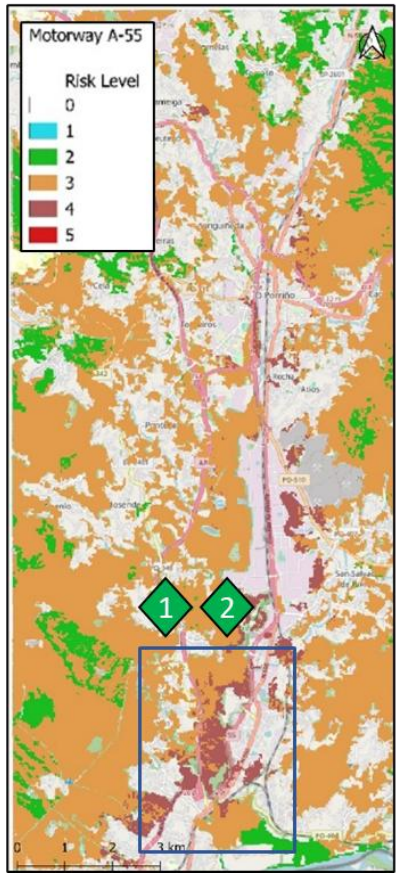
This tool **identifies and locates vulnerable areas** surrounding road and railway infrastructure, aiding in vegetation and risk management by integrating geospatial and remote sensing data with climatic and historical hazard information. In SARIL, forest fire risk maps are simulated for potential fire spread, supporting proactive hazard mitigation. The tool can consider other natural hazards as well.

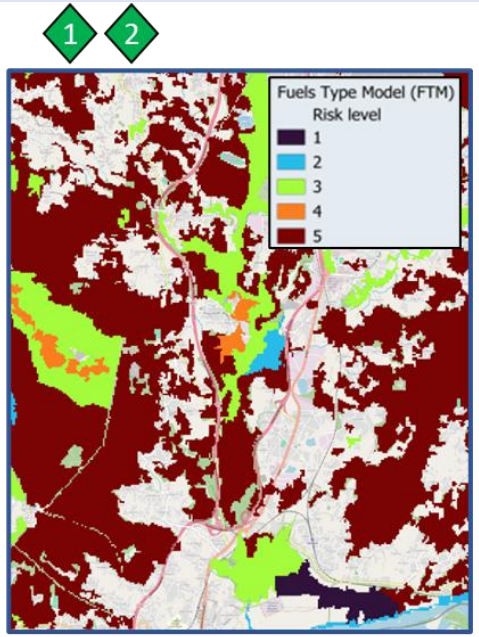
Infrastructure management

Potential mitigation measure 1: Reduction of highly combustible vegetation following the fuel or soil type layer present in the tool.

Potential mitigation measure 2: Management and planting of hazard resilient species typology in areas identified by the tool.

Risk	Rothermel Models	Vegetation
1	2	Agricultural
2	8	Atlantic forest
3	1, 5, 9	Grasslands, pastures, mixed forest
4	3, 6, 10, 11, 12	Heatherlands, Oak groves, pruning and forestry operations
5	4, 7, 13	Pine and eucalyptus forests, pruning and forestry operations





Universidade Vigo

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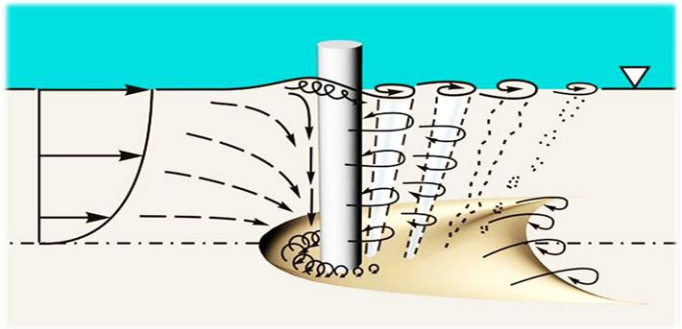
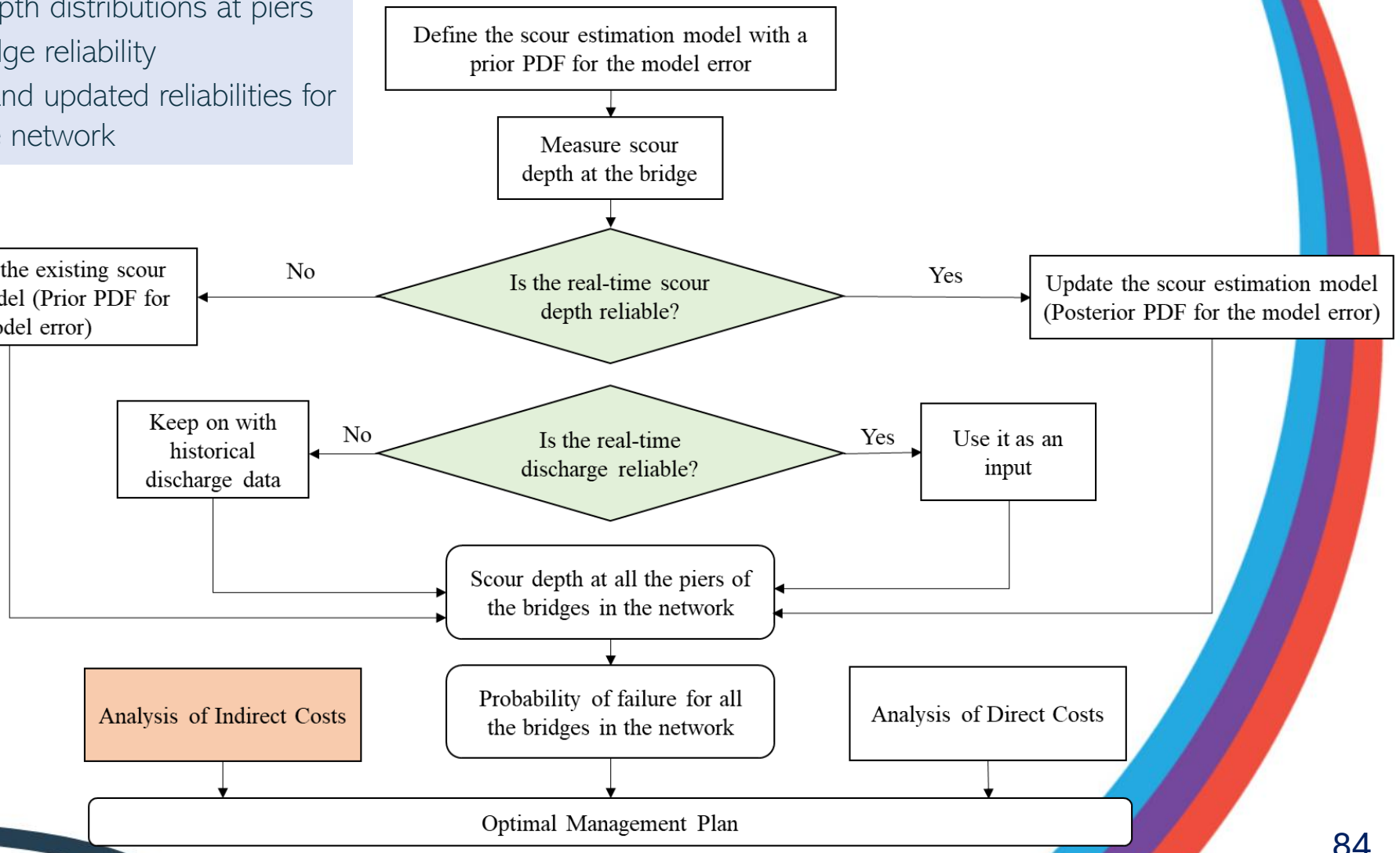
Scour Monitoring for Decision Support

- Scour as a critical driver of bridge failure during floods
- Bayesian Network to update scour depth distributions at piers
- Assessment of impacts on overall bridge reliability
- Integration of consequence analysis and updated reliabilities for risk-based decision-making across the network





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Scour Monitoring for Decision Support

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Key Functions

- **Reliability Assessment:** Continuously updates the reliability of bridges within the network using data from Structural Health Monitoring (SHM) sensors.
- **Emergency Decision Support:** In the event of a flood, the tool provides infrastructure managers with an optimized management plan, determining whether each bridge should remain open or be closed to minimize risk.
- **Securing Monitoring Data Integrity:** Enhancing the reliability and security of scour depth data from monitoring sensors through the cybersecurity tool.

Decision Alternatives and Corresponding Risks (million euros):

Decision_alternatives				Risks
Bridge1	Bridge2	Bridge3	Bridge4	
{["close"]}	{["close"]}	{["close"]}	{["close"]}	-4.7168
{["close"]}	{["close"]}	{["close"]}	{["open"]}	-6.4622
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Disruption Information Interface (DII)

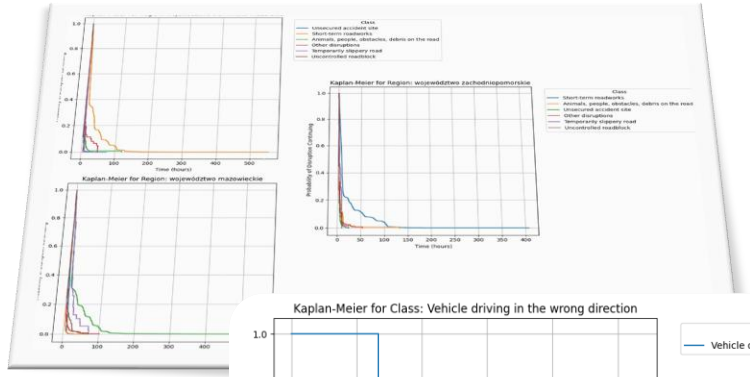
- **Collects,** aggregates and shares data on ongoing disruptions and hazards
- **Forecasts** disruption evolution to support operational decision-making
- **Analyses** historical disruptions to support strategic planning

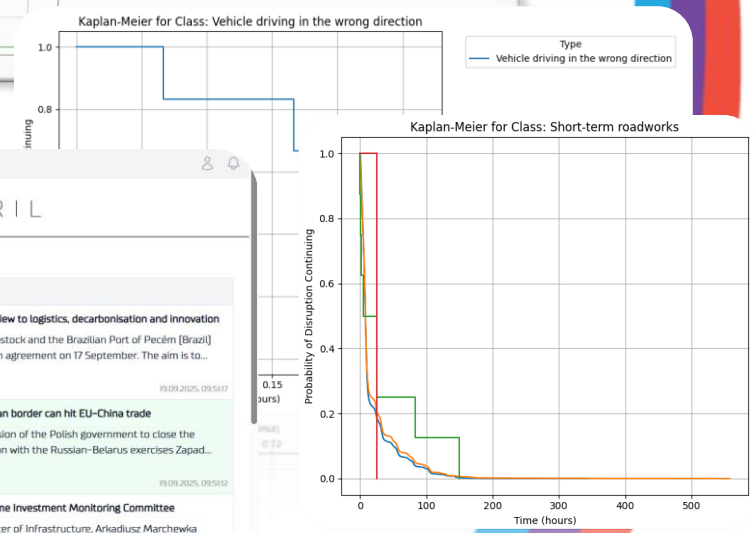
Other (external) disruption

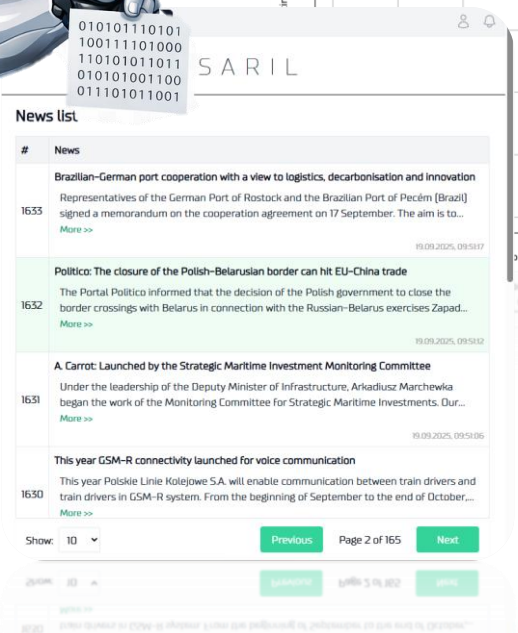
Natural hazard map

Flooding maps

Road capacity



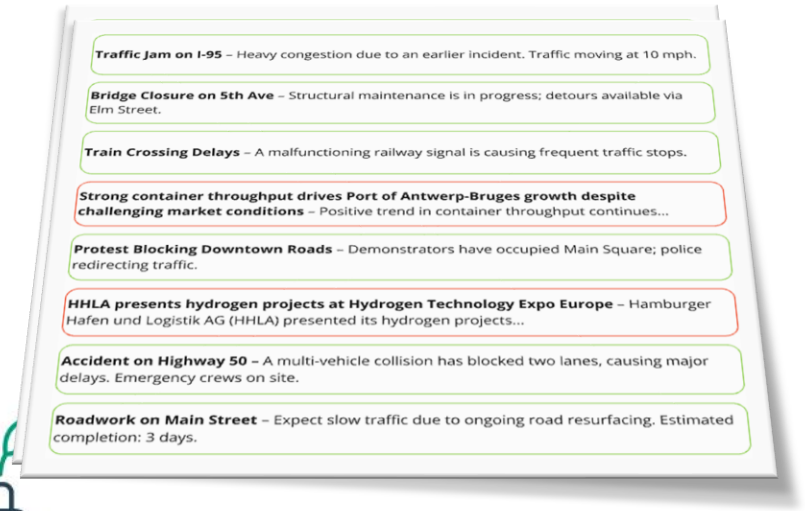


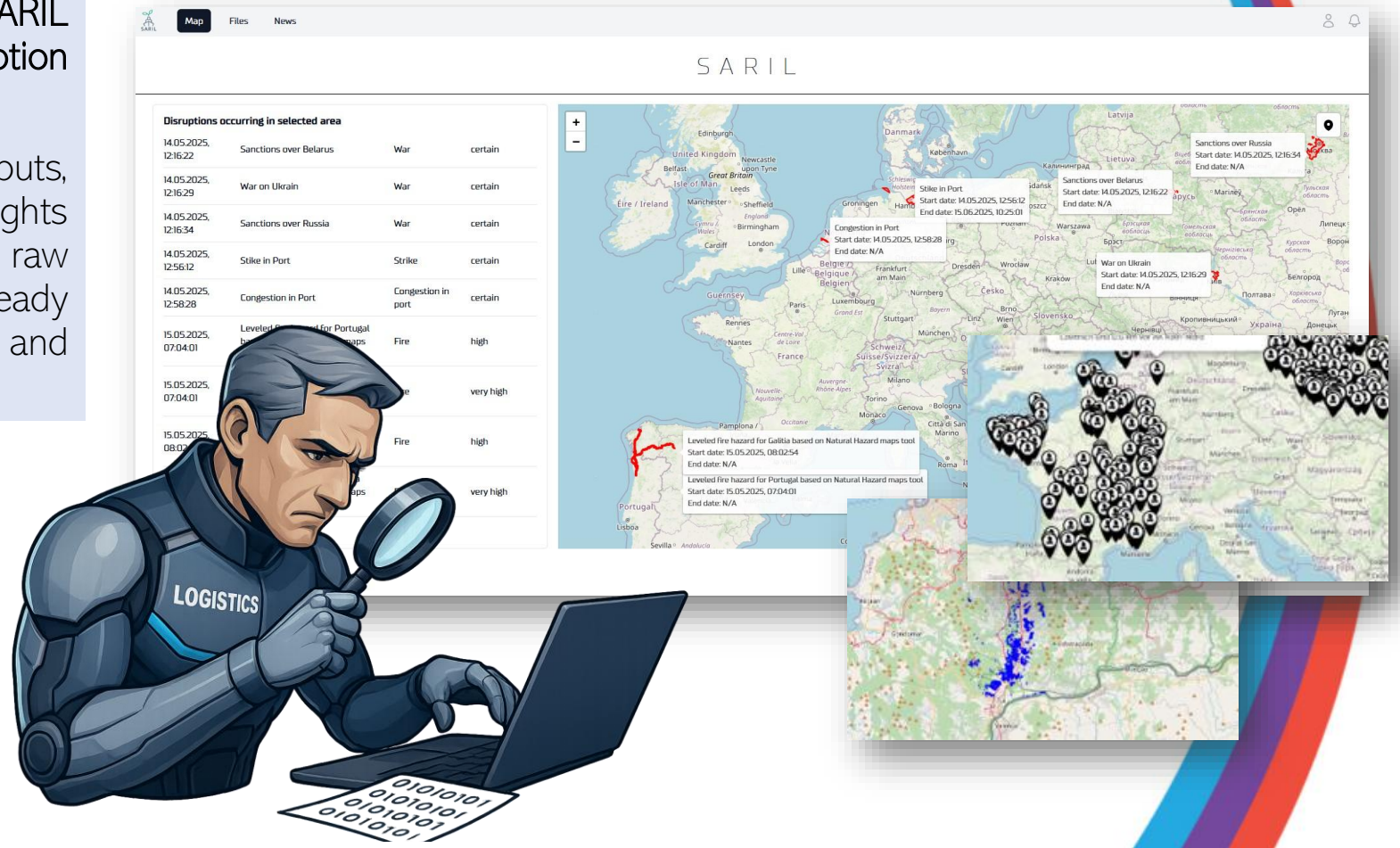


Disruption Information Interface (DII)

The DII is an integration component of the SARIL architecture that aggregates and prepares disruption and hazard information for use across the system.

By filtering noise, structuring heterogeneous inputs, and enriching disruption data with temporal insights such as expected duration, the DII transforms raw observations into consistent, analysis-ready information for downstream simulation, resilience, and strategic planning tools.





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Road Attributes – Energy Module

- Determines shortest vehicle route from a set of waypoints (origin-destination).
- Energy calculations are physics-based and depend on the detailed 3D geometry of the route, as well as the physical properties of the vehicle.

Detailed geometry

Detailed Description

Physics-based computation

Output

- Speed
- Energy consumption
- Fuel consumption
- Direct emissions/particulate matter
- Indirect emissions (LCA)

Detailed along the entire route

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Road Attributes – Energy Module

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Key functions

- Performs detailed calculations of energy consumption in the transport sector (by road, rail, air, and water)
- Estimates energy, fuel consumption, and emissions (CO_2 and NO_X) based on the transport network, infrastructure characteristics, and vehicle type
- User-friendly interface allows users to select origin and destination points on a map, define vehicle characteristics, and specify driving styles, enabling accurate and flexible emission and energy assessments.

Energymodule version:	2025-08-26	**Routing system:**	Built-in router, AStar
Routing network:	NMA/NPRA 2024-11-01	**Processing time:**	17 ms
Warnings:	⚠ 7	**Route summary:**	7,5 km (↑ 199 m, ↓ 71 m)
Time usage:	10 min., 51 sek.	**Average speed:**	42 km/h
Vehicle:	Volvo FH Euro 6, 6x2	**Engine work:**	18,6 KWh
Brake work:	2,7 KWh	**Engine consumption:**	54,3 KWh
Engine consumption per mile:	72 KWh per 10 km	**Regeneration:**	0 KWh
Fuel consumption:	5,5 L diesel, med 19% biodiesel (tungbil)	**Fuel consumption per mile:**	7,3 L per 10 km
Total CO_2e emissions:	16 152 g	**Total NO_x emissions:**	181 g
Average horizon distance:	125,1 m	**Average efficiencies:**	eff_mc: 0,35 eff_gm: 0,85

SARIL

Contact: *sahar.babri@sintef.no*
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SINTEF

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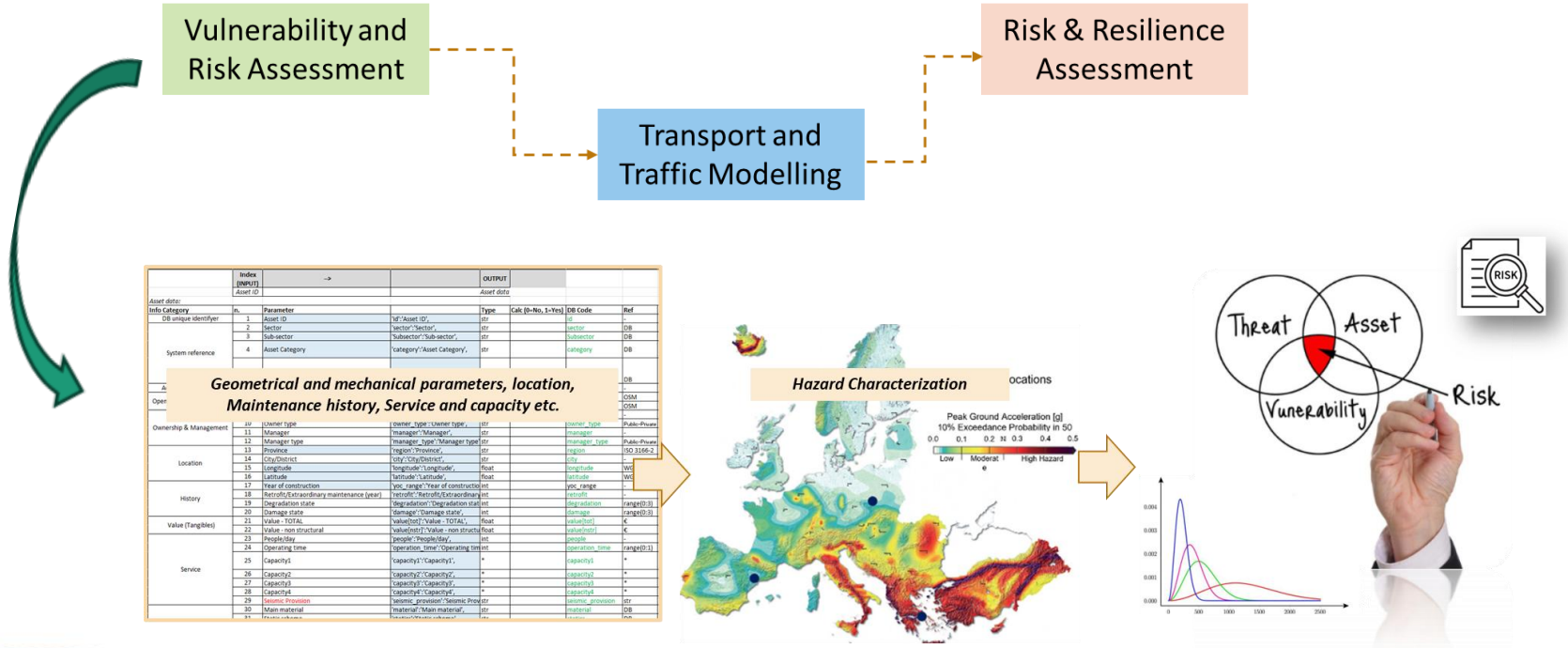
Vulnerability and Traffic Tool

Main functionalities

- **Enhanced Risk Awareness and Preparedness**: To provide a clear understanding of the potential impacts of natural events on the transportation network and communities. This allows authorities, businesses, and individuals to be better prepared for potential
- **Optimized Transportation Planning and Infrastructure Investment**: Inform long-term transportation planning decisions, highlighting vulnerabilities in the network and justifying investments in more resilient infrastructure or alternative routes
- **Minimizing Economic Losses**: By quantifying the potential economic costs associated with travel delays and disruptions caused by natural events, the tool can help in developing mitigation strategies to reduce these losses for businesses and the overall economy.



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Vulnerability and Traffic Tool

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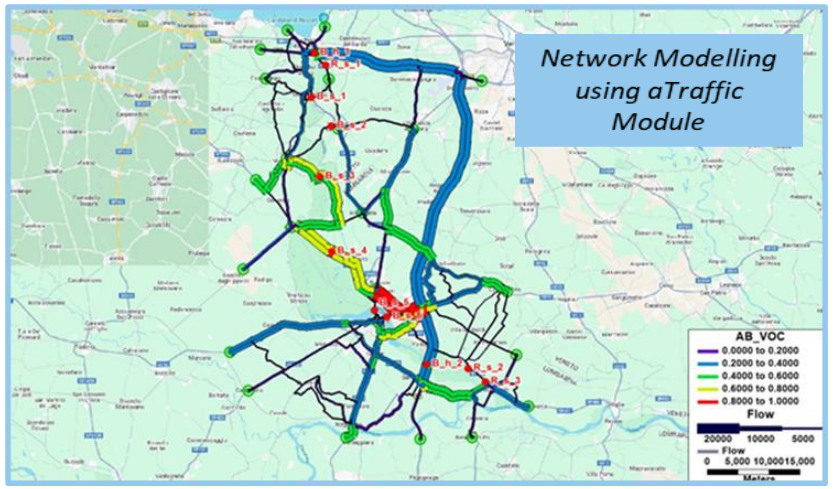
Vulnerability and Risk Assessment

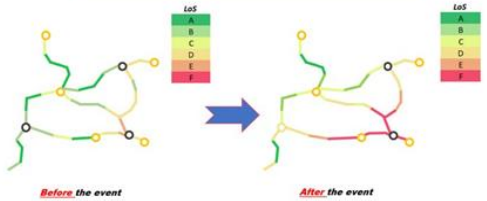
Transport and Traffic Modelling

Risk & Resilience Assessment

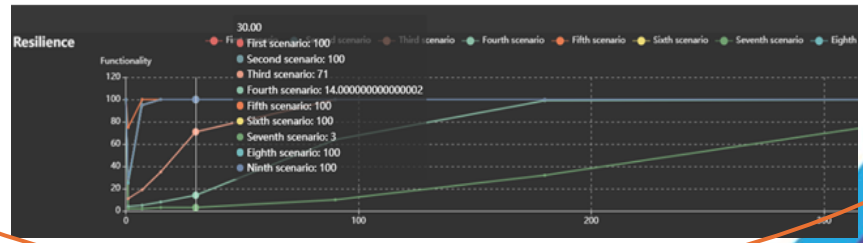


Direct Losses and Indirect Losses

Level of Service BEFORE and AFTER the event



RESILIENCE ASSESSMENT – RECOVERY PHASE



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Traffic Simulation Tool

Universidade do Minho

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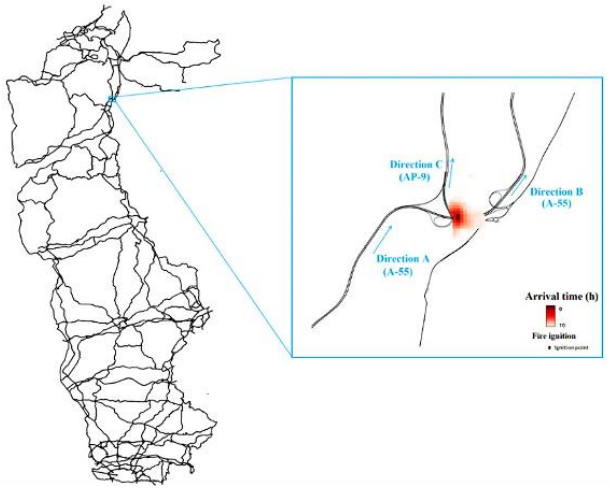
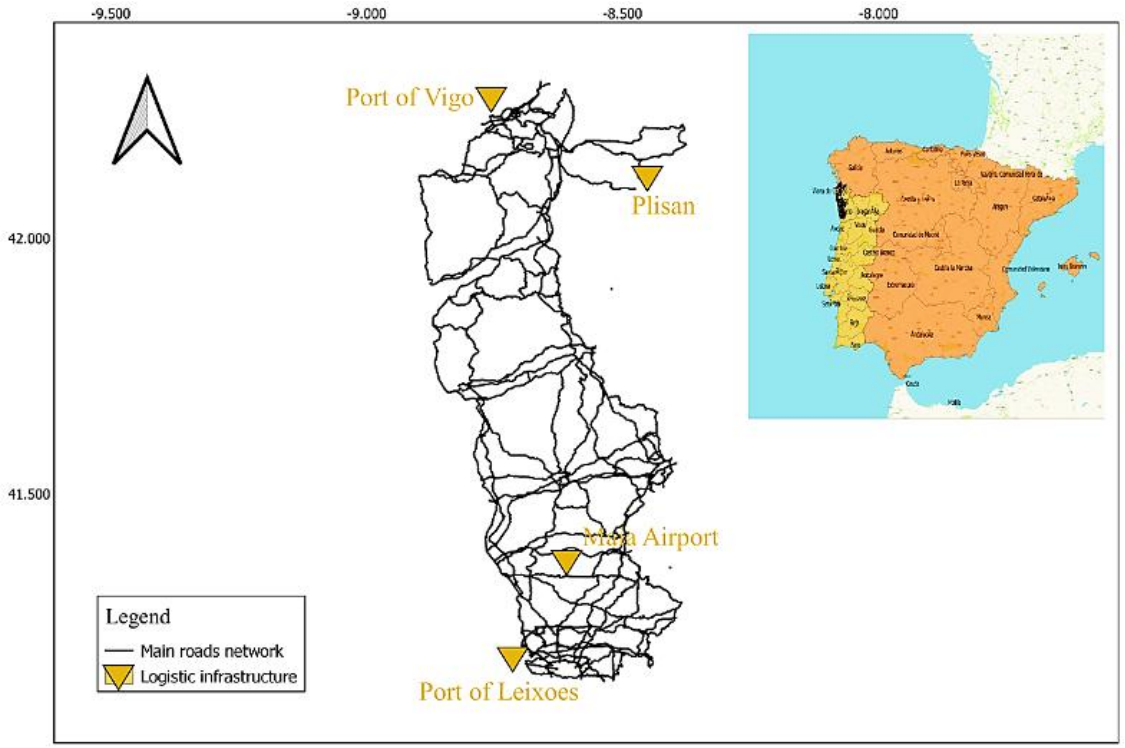
- Disruption impact on traffic scenarios
- Vary the initial traffic distribution
- Quantifies time-dependent resilience of transport networks
- Supports decision-making for planners, policymakers, and logistics operators



Fire propagation on A55 highway



Main road network of the Porto–Vigo corridor, including key logistic infrastructures

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Traffic Simulation Tool

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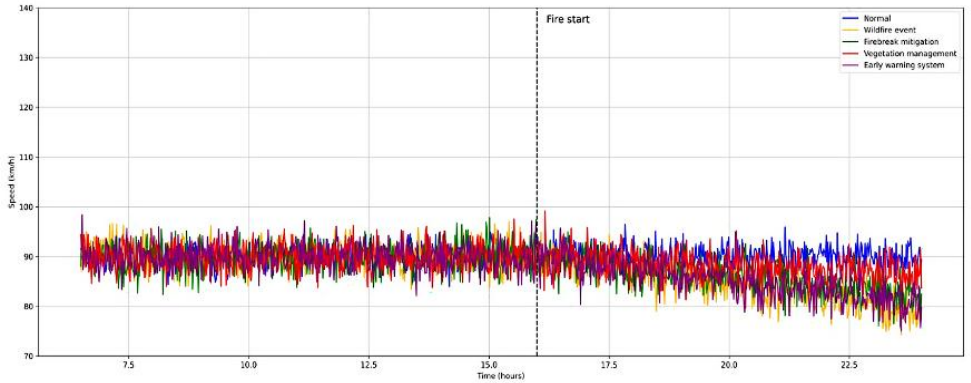
- Develops a dynamic framework to assess time-dependent resilience of transport networks under evolving wildfire conditions
- Integrates hazard modelling and traffic simulation through a GIS-based coupling mechanism for realistic disruption representation
- Evaluates resilience performance indicators
- Assesses the effectiveness of diverse mitigation strategies (environmental, structural, and digital) within a unified framework
- Provides a scalable and transferable tool for multi-hazard resilience analysis and decision support for planners and policymakers



Comparing the heavy vehicle average speeds during A-55 fire event with and without mitigation measures application

Overall O-D trip assessment for the study area during fire disruption

	Event/ Measure	Avg trip duration (s)	Increase (%)	Avg travel speed (km/h)	Reduction (%)	Avg lost time (s)	Increase (%)	CO2 emission (t)	Increase (%)
Light vehicles	Base event	1500	0	120	0	20	0	200	0
	A-55 fire event	1560	4	113	6	21	5	214	7
	Firebreak measure	1545	3	115	4	21	3	210	5
	Forest mass management measure	1500	0	120	0	20	0	200	0
	Early warning digital system measure	1552.5	3.5	114	5	21	4	208	4
Heavy vehicles	Base event	2000	0	90	0	30	0	500	0
	A-55 fire event	2120	6	82	9	32	7	545	9
	Firebreak measure	2080	4	85	6	32	5	530	6
	Forest mass management measure	2000	0	90	0	30	0	500	0
	Early warning digital system measure	2100	5	83	7.5	32	6	520	4

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Agent-based simulation for Resilience of Intermodal Transportation (ASTROIT)

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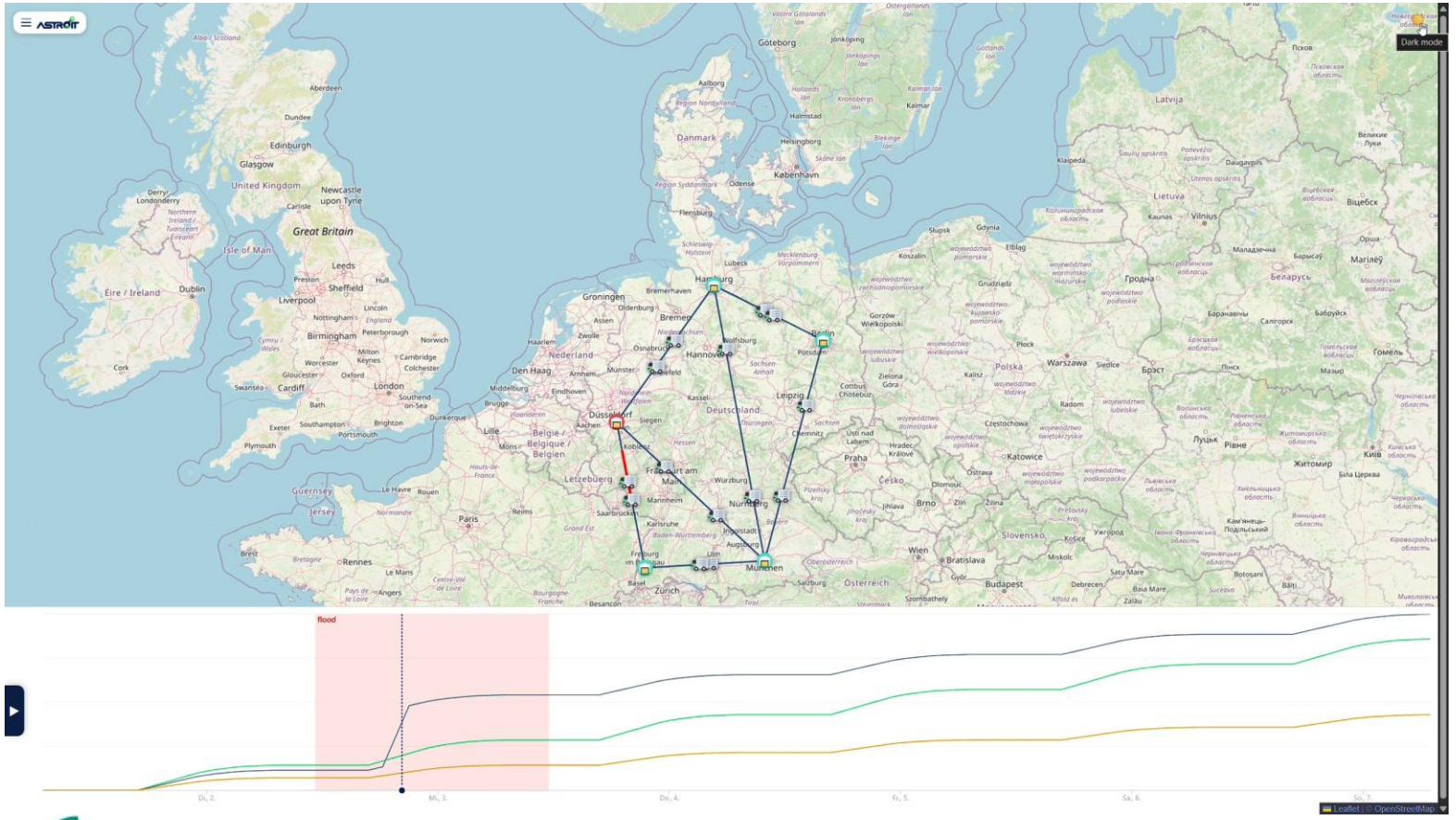
Agent-based simulation for Resilience of Intermodal Transportation



Fraunhofer EMI

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Agent-based simulation methods

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SARIL Scenarios Dashboards

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SARIL Dashboards for Green & Efficient Decision Making

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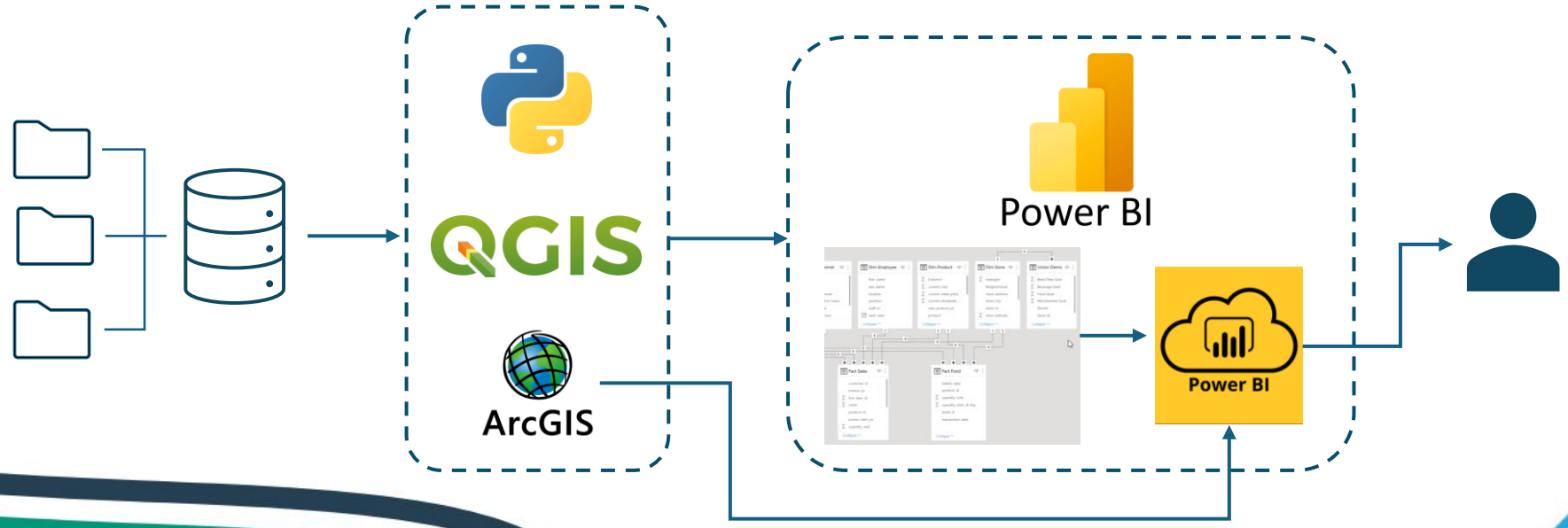
SARIL Outputs & Decision Support

- SARIL tools generate insights to improve logistics system management
- Support faster, higher-quality decision-making
- Enable optimisation of key parameters (fuel consumption, CO2 emissions)
- Contribute directly to green resilience objectives

Interactive Dashboards

- Developed as a centralized, user-friendly platform
- Present data in an accessible and intuitive format
- Integrate tool outputs with green resilience assessment results



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SARIL Dashboards for Green & Efficient Decision Making

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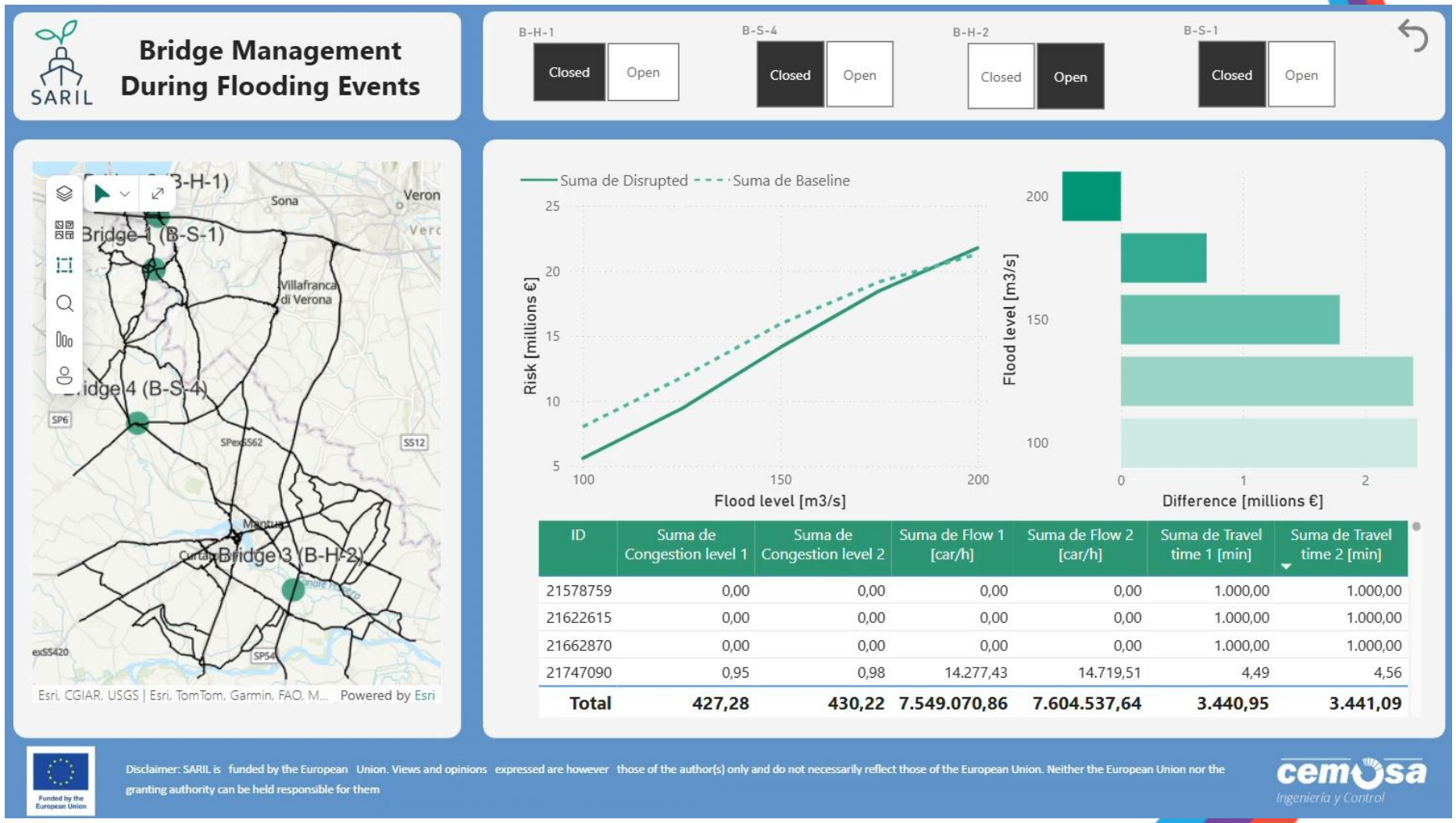

ID	Suma de Congestion level 1	Suma de Congestion level 2	Suma de Flow 1 [car/h]	Suma de Flow 2 [car/h]	Suma de Travel time 1 [min]	Suma de Travel time 2 [min]
21578759	0,00	0,00	0,00	0,00	1.000,00	1.000,00
21622615	0,00	0,00	0,00	0,00	1.000,00	1.000,00
21662870	0,00	0,00	0,00	0,00	1.000,00	1.000,00
21747090	0,95	0,98	14.277,43	14.719,51	4,49	4,56
Total	**427,28**	**430,22**	**7.549.070,86**	**7.604.537,64**	**3.440,95**	**3.441,09**

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SARIL Business models and recommendations

Marta Waldmann (L-PIT/SARIL)

20/05/2026

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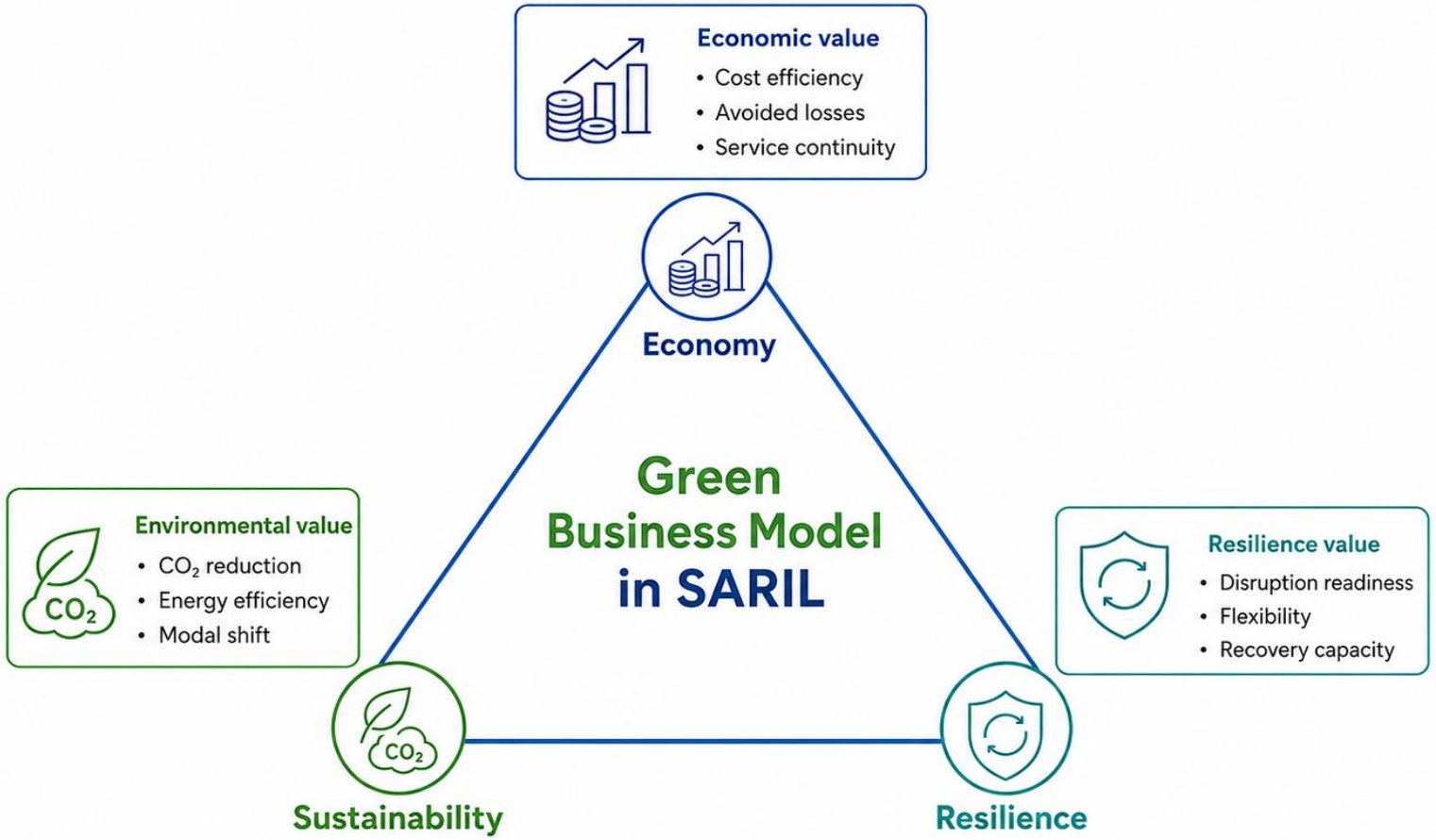
What makes a business model “green” in SARIL?

A green business model combines economic, environmental and resilience value



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Business models and recommendations

SARIL enables a shift from cost to value – building a sustainable, resilient and competitive freight transport and Logistics system

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Business model archetypes by role

R1 Role 1 – Infrastructure Managers

Infrastructure managers, road, rail and port operators, and entities responsible for traffic management

Scope of responsibility

- Lifecycle infrastructure management
- Monitoring and predictive maintenance
- Sharing infrastructure status data
- Investment in resilience

Business model logic

Building infrastructure that is more reliable, data-driven and supported by monitoring and predictive maintenance, in order to strengthen resilience and continuity of operations.

Example business models

- Lifecycle-Optimised Green Infrastructure
- Green Infrastructure-as-a-Service
- Circular Infrastructure Investment

R2 Role 2 – Logistics Network Configurators

Entities responsible for strategic logistics network design: selection of hubs, corridors, partners, terminals and transport modes.

Scope of responsibility

- Selection of hubs and corridors
- Selection of partners and terminals
- Selection of transport modes
- Optimisation of cost, emissions, delivery time and resilience

Business model logic

Designing logistics networks that already at the planning stage combine cost efficiency, lower emissions, greater flexibility and higher resilience to disruptions.

Example business models

- Sustainability-Weighted Network Configuration
- Green Corridor Strategy
- Resilience-Embedded Network Planning

R3 Role 3 – Logistics Operators and Shippers

Entities responsible for the day-to-day management of freight flows.

Scope of responsibility

R3a – Operational orchestration

- Managing flows in real time
- Selection of routes and transport modes
- Response to disruptions

R3b – Carrier and terminal operations

- Physical execution of transport
- Terminal handling
- Delivery of operational services

Business model logic

Providing greater operational flexibility, faster response to disruptions and more efficient use of resources in the day-to-day management of freight flows.

Example business models

- Synchromodal Orchestration Platform
- Disruption Monitoring & Replanning / Resilience-as-a-Service
- Load Pooling Marketplace
- Green Fleet & Carrier Management
- Zero-Emission Urban Last-Mile
- Green Intermodal Terminal Operations

Infrastructure level
Resilient and sustainable infrastructure

→

Network design level
Strategic design of green and resilient logistics networks

→

Operational level
Efficient and flexible operations in daily logistics

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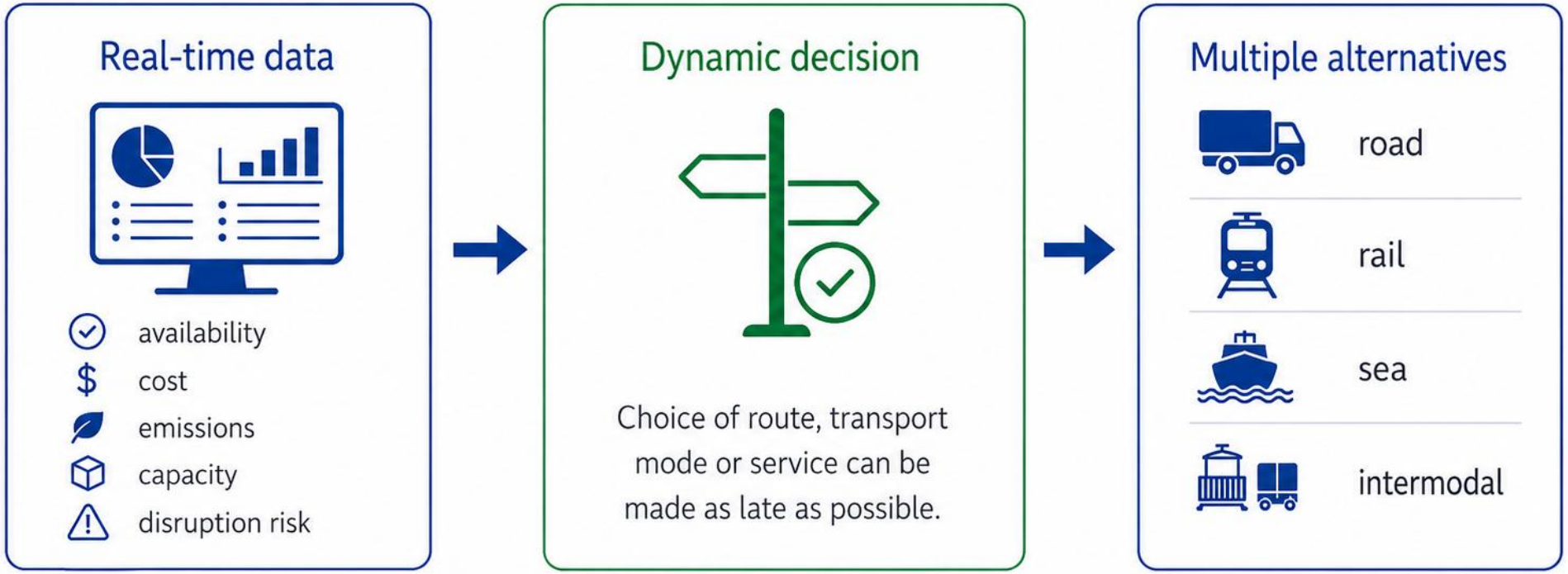
Synchromodality model – flexible choice

Transport decisions are made dynamically based on real-time data.



Instead of a rigid chain: a flexible network, faster response, greater resilience.

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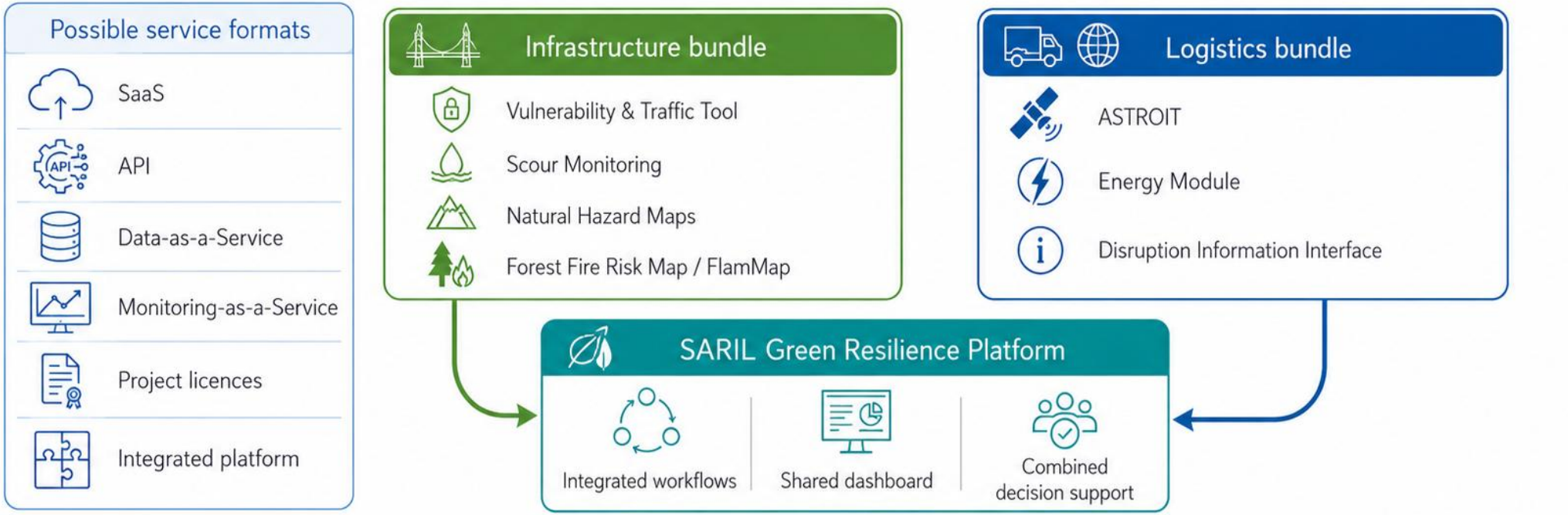
SARIL tools as business model enablers

SARIL tools are not only research outputs, but potential service components.



The most comprehensive commercialisation option.

What these tools enable

- Disruption intelligence
- Simulation-based planning
- Monitoring
- Emissions assessment (CO_2)
- Dynamic decision-making

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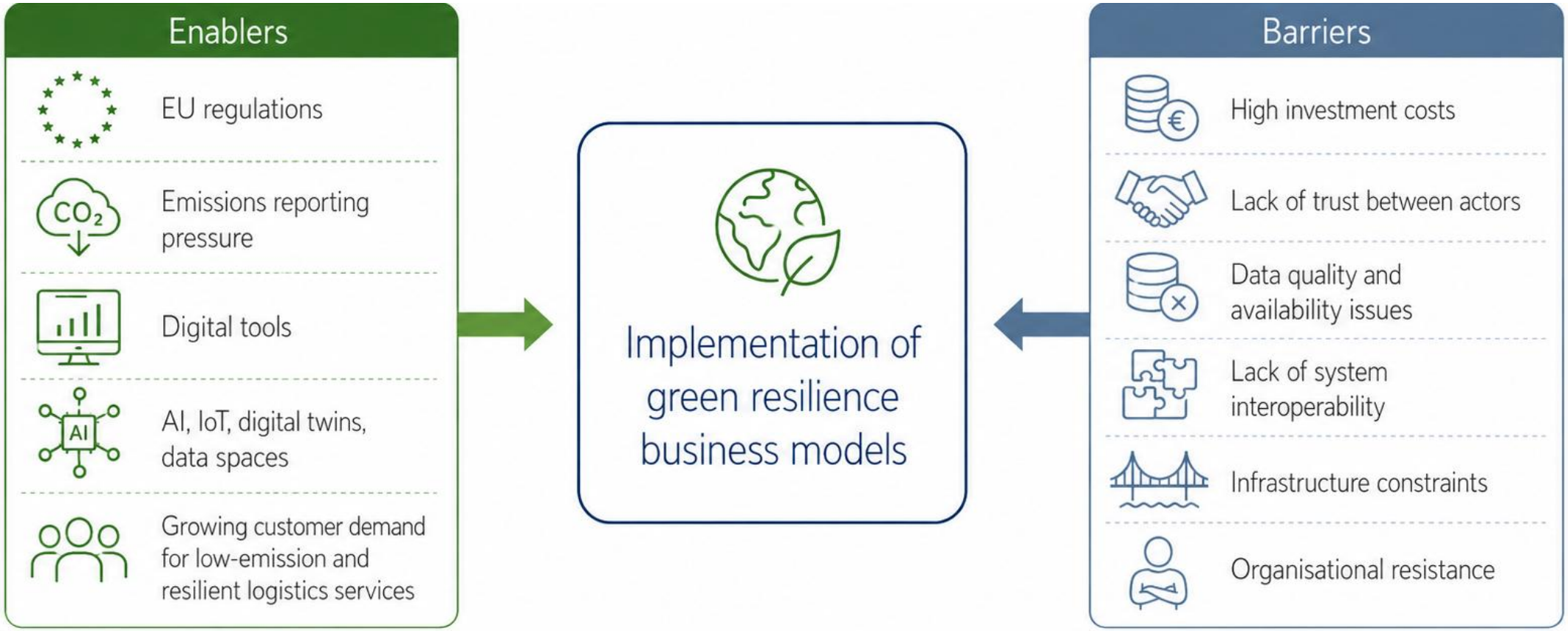
Implementation of business models



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Recommendations: structure and purpose

Stakeholder engagement → **Insights gathered** → **Role-based recommendations**

Stakeholder engagement

- 3 stakeholder workshops
  Italy • Poland • Spain
- Surveys
- Interviews

Insights gathered

Needs, challenges and practical expectations

Role-based recommendations

- **R1** Infrastructure Managers
- **R2** Logistics Network Configurators
- **R3** Logistics Operators and Shippers

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Recommendations for Role 1 – Infrastructure Managers

Key challenges

Transport infrastructure faces increasing disruption risks:

- Climate-related hazards (floods, storms, wildfires)
- Ageing infrastructure
- Limited redundancy in critical corridors
- Insufficient integration between infrastructure status and logistics operations

Infrastructure managers need tools enabling:

- Vulnerability assessment
- Real-time monitoring
- Disruption-aware traffic management

Key messages

Infrastructure resilience should be strengthened through:

- Infrastructure monitoring and early warning systems
- Integration of infrastructure data into logistics decision-making
- Improved risk and vulnerability assessment
- Coordination between infrastructure managers and logistics actors

SARIL tools supporting this role:

- Vulnerability & Traffic Tool
- Scour Monitoring Decision Support
- Disruption Information Interface

From reactive crisis response to proactive, data-driven resilience by design.

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Recommendations for Role 2 – Logistics Network Configurators

Key challenges

Strategic logistics network design often suffers from:

- dependence on specific transport corridors
- limited multimodal flexibility
- rigid network structures
- insufficient consideration of disruption risks in network planning

Strategic decisions should incorporate:

- resilience analysis
- alternative routing options
- multimodal transport solutions

Key messages

Network resilience can be improved through:

- designing logistics networks with redundancy
- integrating multimodal transport solutions
- evaluating alternative network configurations
- using simulation tools to assess disruption impacts

SARIL tools supporting this role:

- Transport simulations (ASTROIT)
- Route Attributes Energy Module
- Disruption Information Interface

These tools allow simulation of alternative logistics network configurations.

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Recommendations for Role 3 – Logistics Operators and Shippers

Operational challenges

Daily logistics operations are strongly affected by disruptions:

- limited real-time information about disruptions
- strong time pressure in decision-making
- complex coordination between actors
- difficulties in rerouting cargo flows

Operators need tools enabling:

- real-time disruption awareness
- dynamic routing decisions
- coordination across the logistics network

Key messages

Operational resilience can be improved through:

- real-time disruption information
- dynamic routing and mode switching
- improved coordination across logistics actors
- use of digital decision-support tools

SARIL tools supporting this role:

- Disruption Information Interface
- Route Attributes Module
- Transport simulation tools

These tools enable dynamic operational decision-making during disruptions.

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Final key messages

1 Design principle

Resilience and sustainability must be designed together.

Green resilience is not only a technical concept, but a planning and management principle.

2 Deployment logic

Business models are needed to make SARIL results deployable.

They define value propositions, incentives, revenue logic and measurable KPIs.

3 From knowledge to action

Recommendations turn SARIL knowledge into action.

They provide practical guidance for implementation and decision-making.

4 Shared responsibility

Infrastructure managers, network configurators, logistics operators and policymakers each have a specific role in building a resilient and sustainable freight transport system.

SARIL supports the shift from disruption response to resilience by design.

Tools, business models and recommendations work together to enable green resilience in freight transport and logistics.

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Addressing Maritime Transport and Logistics Needs through SARIL Tools: The Port of Vigo Case Study

Diana Noriega (Port Authority of Vigo/SARIL)

20/05/2026

PARTNERS

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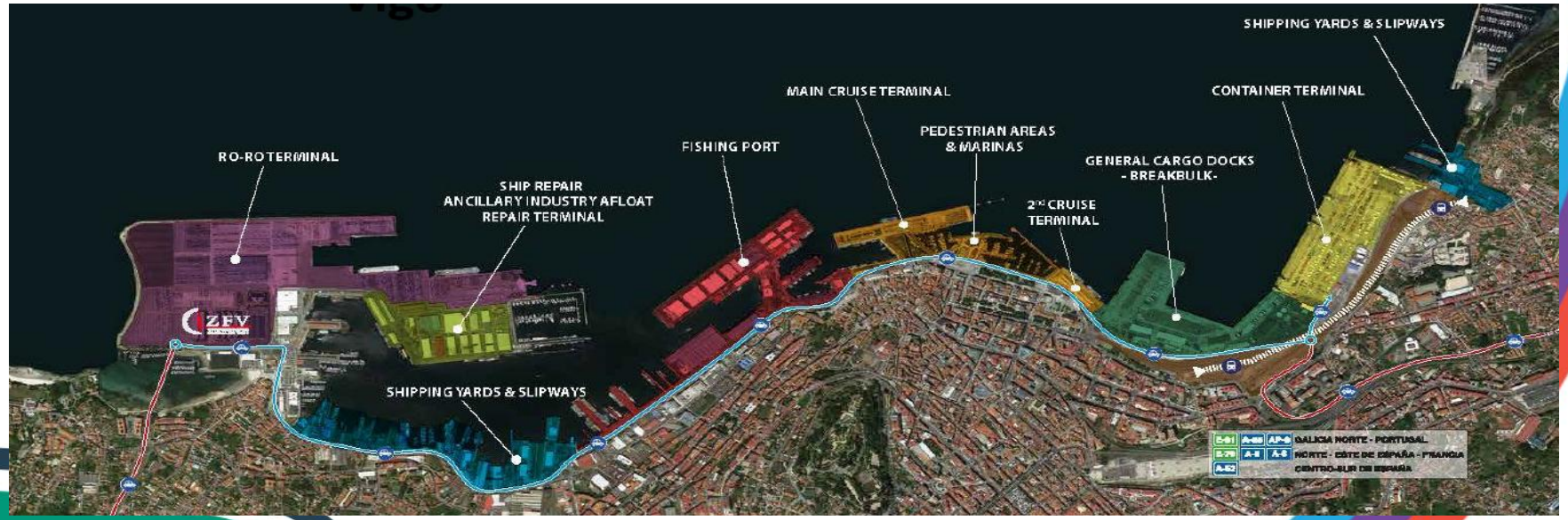
Case study: The Port of Vigo. Brief Presentation.

- Port of **General Interest of the Spanish State**. Located in the NW of Spain (Galicia)
- Important **hub for the transport and logistic sector in the Atlantic maritime traffic** - links with EU countries and main international ports
- Mainly general cargo and comercial goods: **Automotive and frozen fish** ~ 5,5 Ktons/year (94%$_T$)



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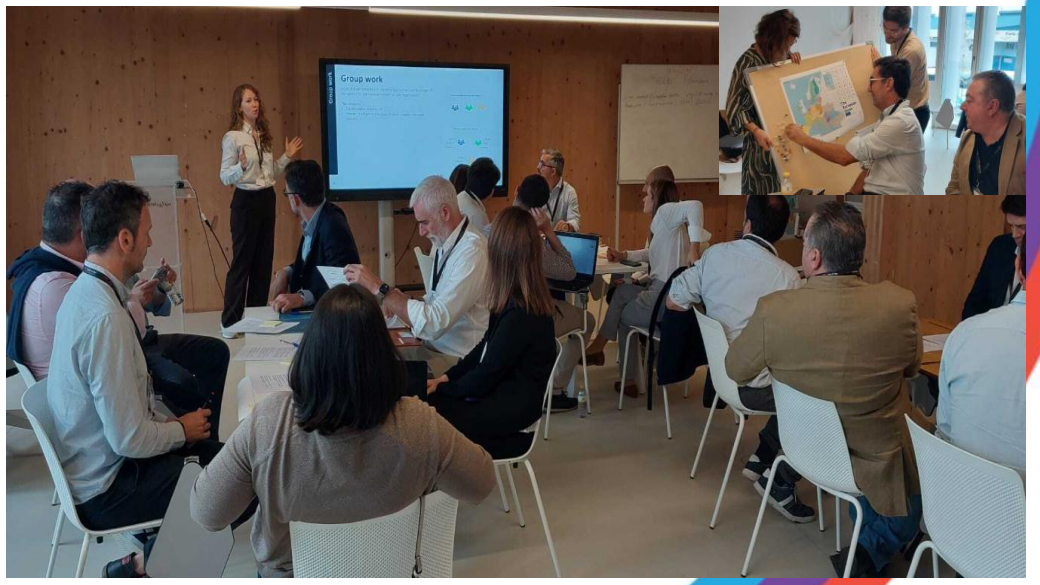
Main needs and challenges identified by stakeholders

- **Better data collection and sharing** across port and logistics stakeholders (cybersecurity, confidentiality and competition)
- Increasing disruptions linked to **extreme weather events, social unrest and operational delays**
- Importance of a **joint digital platform** supporting both **operational and strategic decision-making**
- Key challenge **lack of coordination between actors and governance levels -** need for stronger collaboration
- **Resilience and sustainability should be addressed together**, although environmental priorities are often secondary during emergencies



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Potential application of tools developed

- Several of the tools generated **strong interest among port operational and management stakeholders** due to their high potential for adaptation to specific operational needs
- The tools not only **assess energy and traffic parameters** to help reduce potential disruptions — such as delays and increased costs — but also **address infrastructure-related risks**, of critical importance in port environments
- **High potential for practical implementation** in port environments

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Next steps & Future perspectives

- Real implementation and testing in pilot ports; **Port of Vigo** (Spain) and **Port of Leixões** (Portugal)
- **High replication potential** across EU and international ports, with further adaptation and validation in real operational environments
- New opportunities for **EU proposals and cross-sector collaboration**, whilst strengthening the **SARIL consortium** network

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END-USER PERSEPECTIVE

From daily disruptions to resilient logistics

Logistics Operator perspective

Mariusz Graca (CSL Sp. z o.o. / SARIL)

20/05/2026

PARTNERS

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Daily logistics reality

- Constant disruptions
- High uncertainty
- Time-critical decisions
- Information overload

- Better decisions require better information

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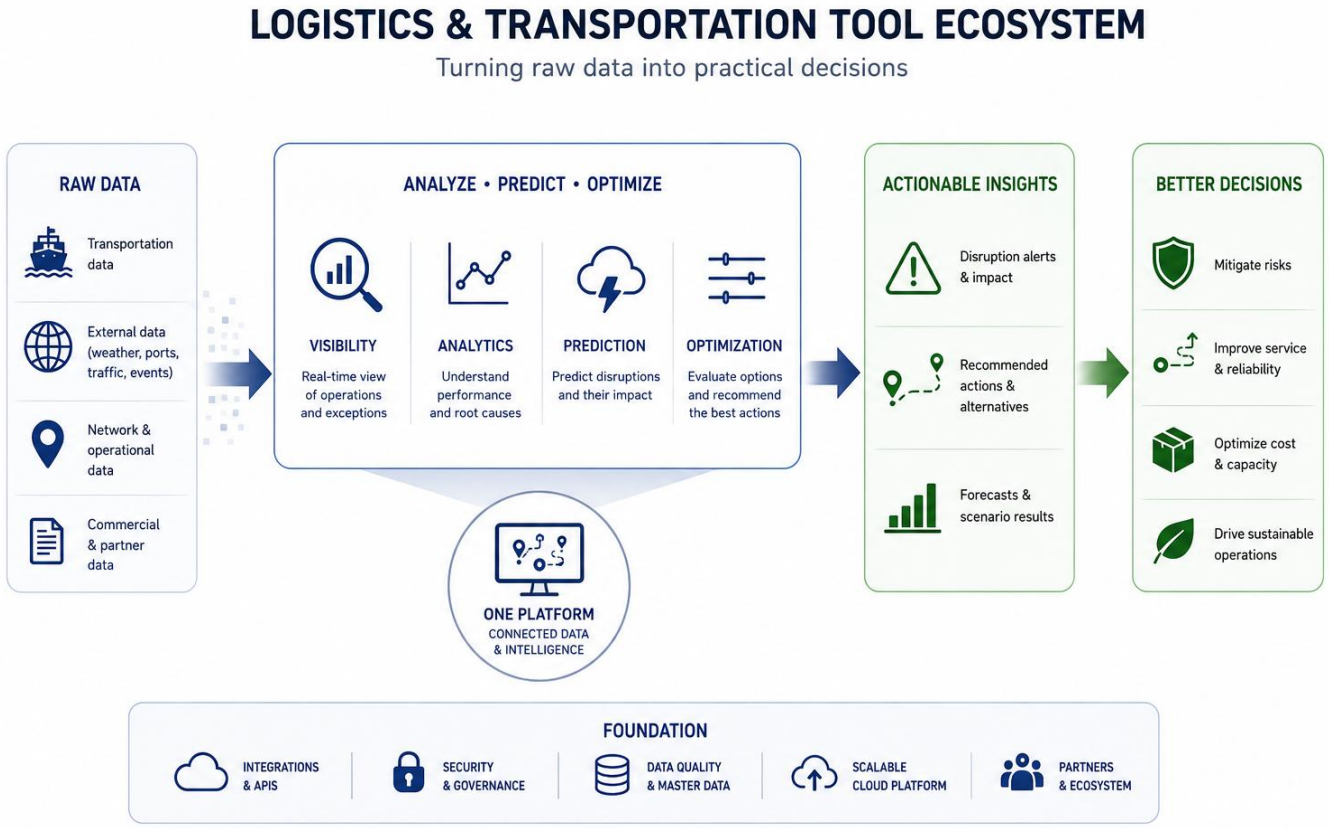
From data to resilience

- Real-time disruption awareness
- Network & scenario modelling
- Sustainable optimisation

- Turning complexity
  into actionable insight



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Key takeaways

- Integrated view of disruptions
- Decision support, not just data
- Resilience as capability
- Sustainability in daily planning

- Resilience
  =
  Competitive advantage

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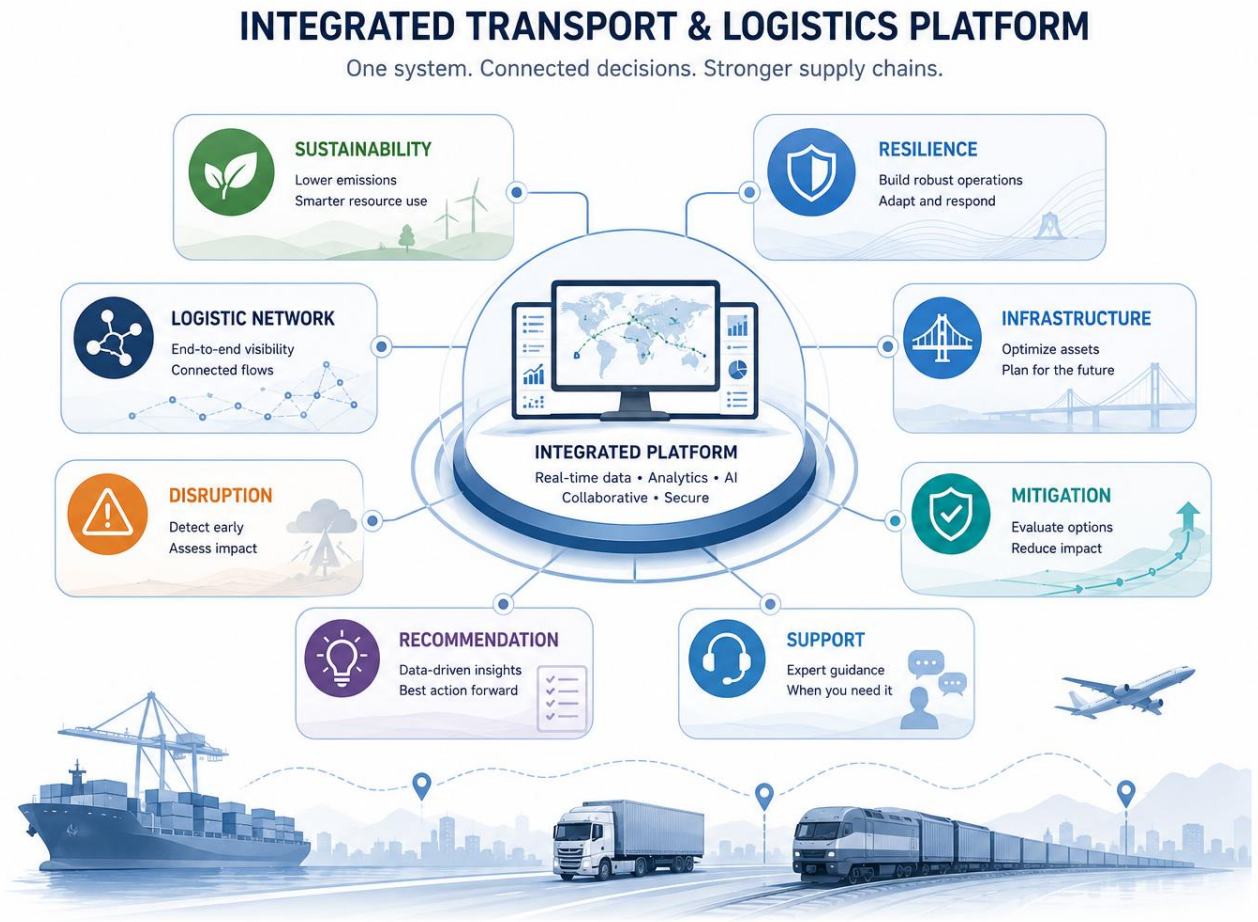
Our feedback

- Strong practical relevance
- High operational potential
- Worth further development

- We would use it
  if available on the market



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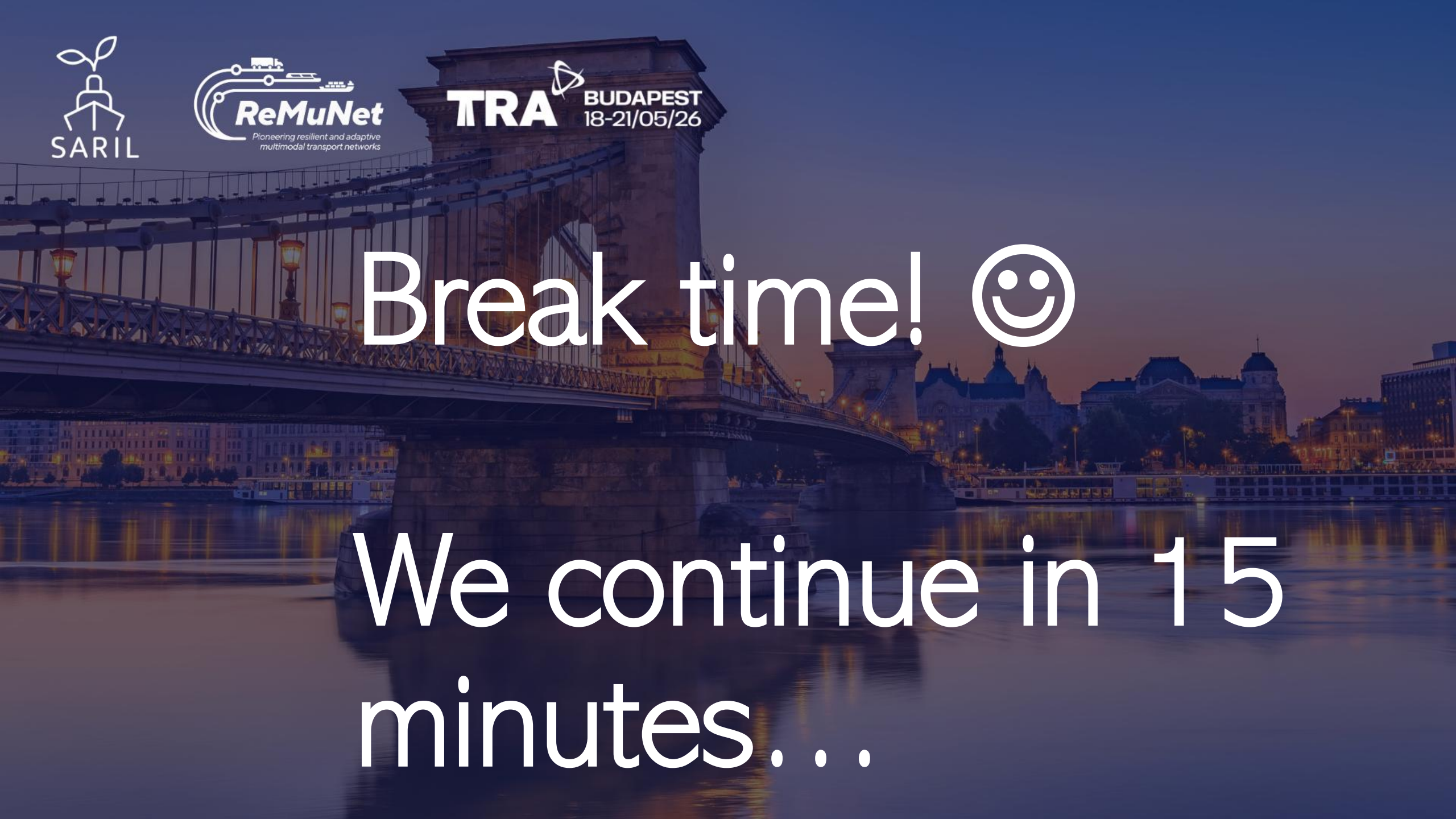
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TRA
BUDAPEST
18-21/05/26
Break time! ☺
We continue in 15 minutes…

Alan McKinnon
Professor of Logistics,
Kühne Logistics University

Sophie Punte
Co-founder and CEO,
Life-Links

Arnd Hoppe
Project Manager Corporate HSQ
& Customers, Gebrüder Weiss

Sandra Stein
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PANEL DISCUSSION

Resilient Multimodal Transport Networks: From Research to Real-World Impact

ReMuNet
Pioneering resilient and adaptive multimodal transport networks

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TRA BUDAPEST 18-21/05/26

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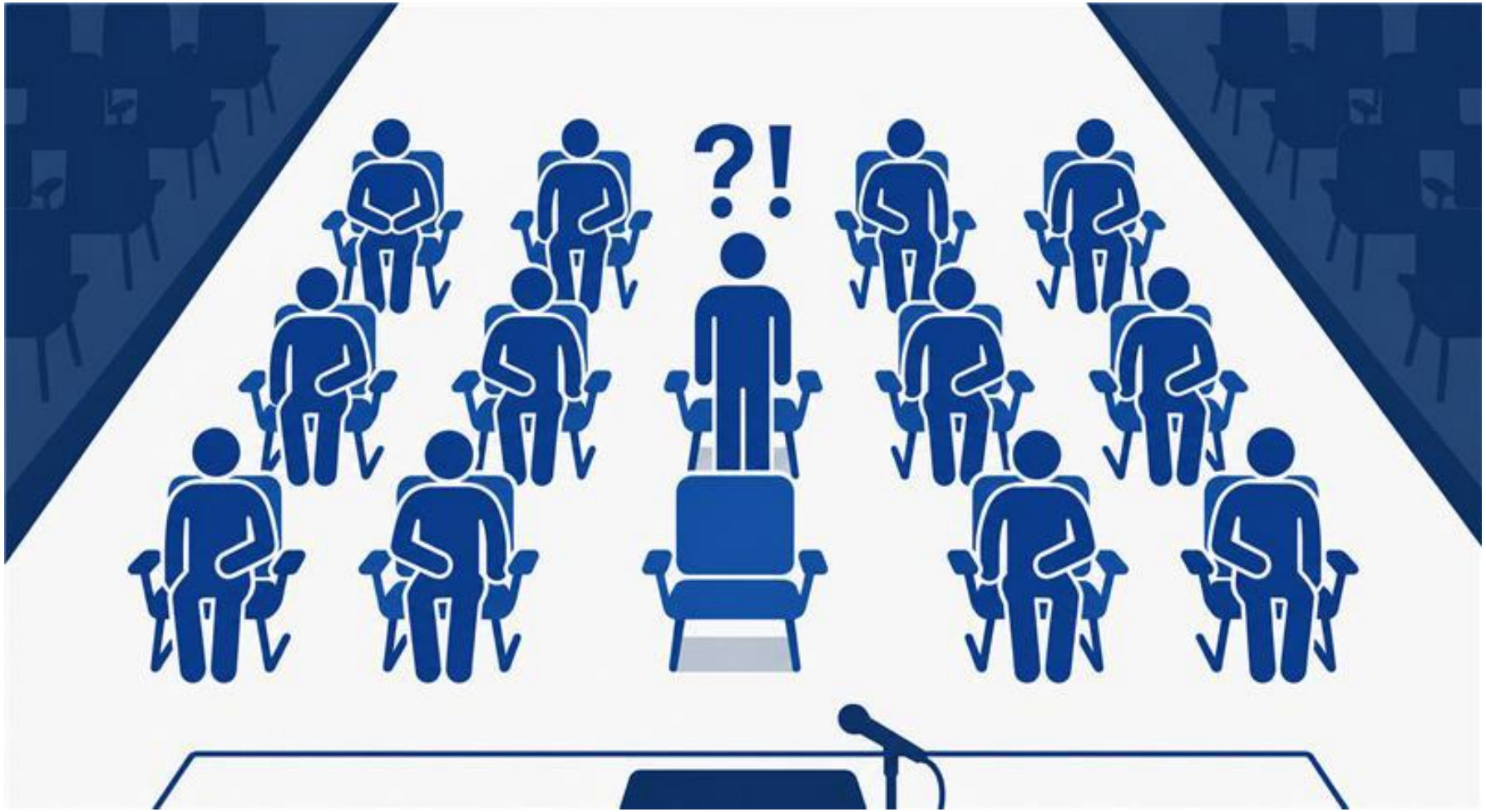
Do you have any questions?



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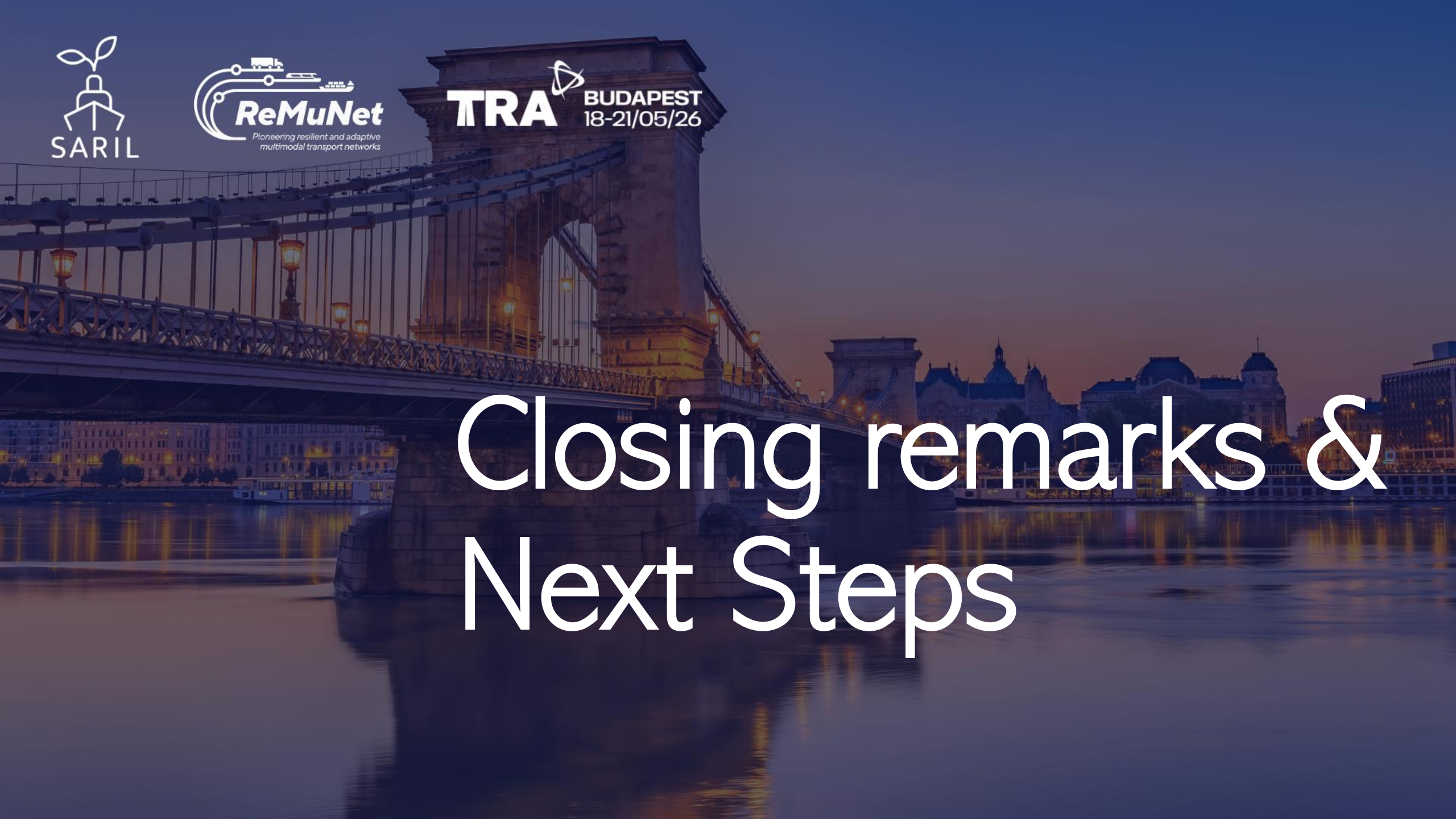

Closing remarks & Next Steps

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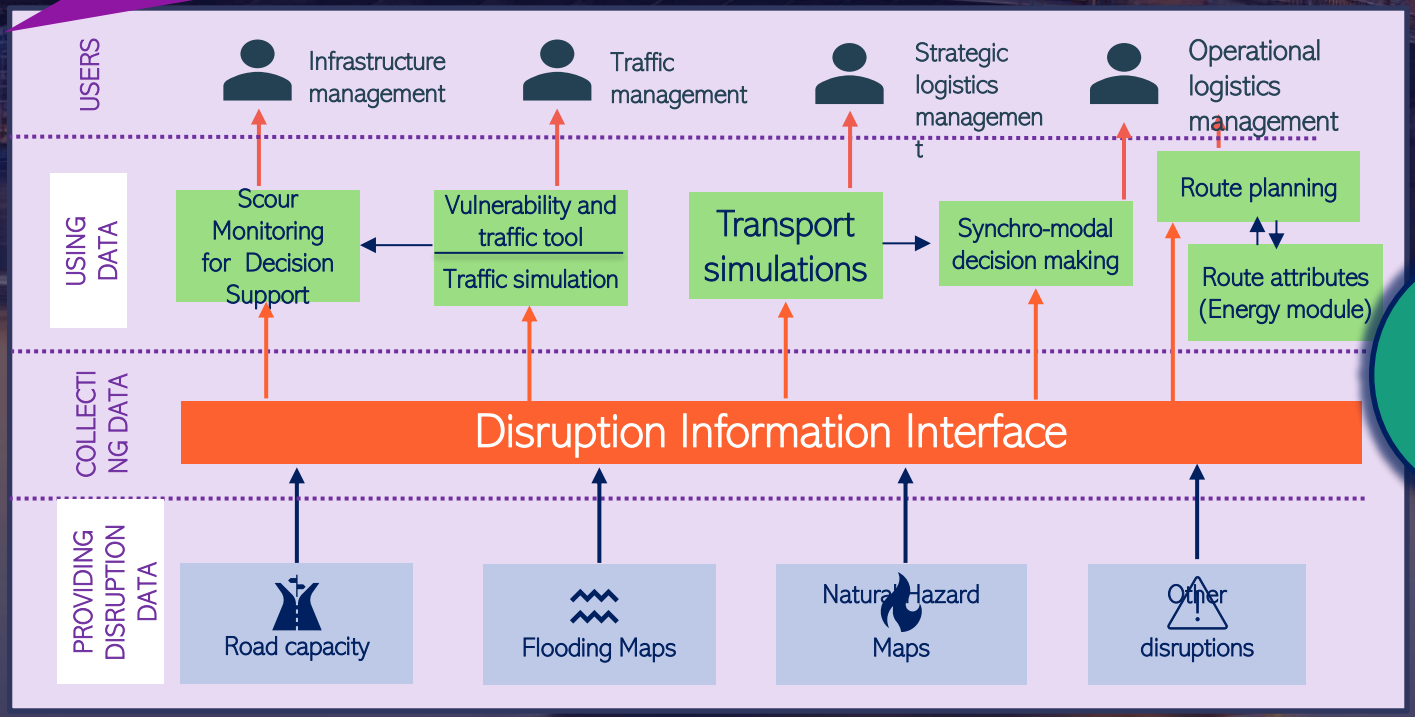
Clear call for interoperable, user-friendly tools, combining real-time operations and planning analytics

Sustainability is only/mainly considered in ‚good weather conditions.



SARIL toolkit

R1

R2

R3

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Future research is needed to enable synchromodality and increase resilience

- Further **connection** of industry stakeholders to create collaborative business models
- Improve **standardisation** of data exchange and communication across Europe
- Connect **data bases** of companies, institutes, governmental entities while ensuring data sovereignty and security
- Improve **on real-time data** transmission and **event-forecasting** to enhance disruption management
- Optimize supply chain management by integrating **AI algorithms**

Thank you for your attention!

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