ReMuNet

Pioneering resilient and adaptive multimodal transport networks

D3.6

Digital handover protocols for multimodal relay transport

MANSIO GmbH

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ABBREVIATIONS

API	Application Programming Interface
ILU	Intermodal Loading Unit
POD	Proof of Delivery
SME	Small and Medium Enterprises
TEU	Twenty-Foot-Equivalent Unit

Executive Summary

The truck-to-truck road relay transport system with trailer swapping, as organized by the software company MANSIO, offers an innovative solution for overcoming disruptions in multimodal transport networks. By bridging blocked connections between terminals, it enables alternative routing options and integrates local carriers into larger multimodal transport ecosystems.

To ensure a secure and traceable handover process—particularly for tracking potential damage to intermodal loading units—handover protocols are essential. These protocols are carried out by truck drivers and terminal operators at designated handover points and at terminals.

For the ReMuNet project, a configurable and integrable mobile application prototype has been developed to support operational staff during equipment handovers at terminals and truck-to-truck relay stations along the road. This application interfaces with the ReMuNet platform and is specifically designed to meet the handover requirements of intermodal transport units.

1. The concept of Relay Transport

1.1 Truck-to-truck relay transport as new routing alternative

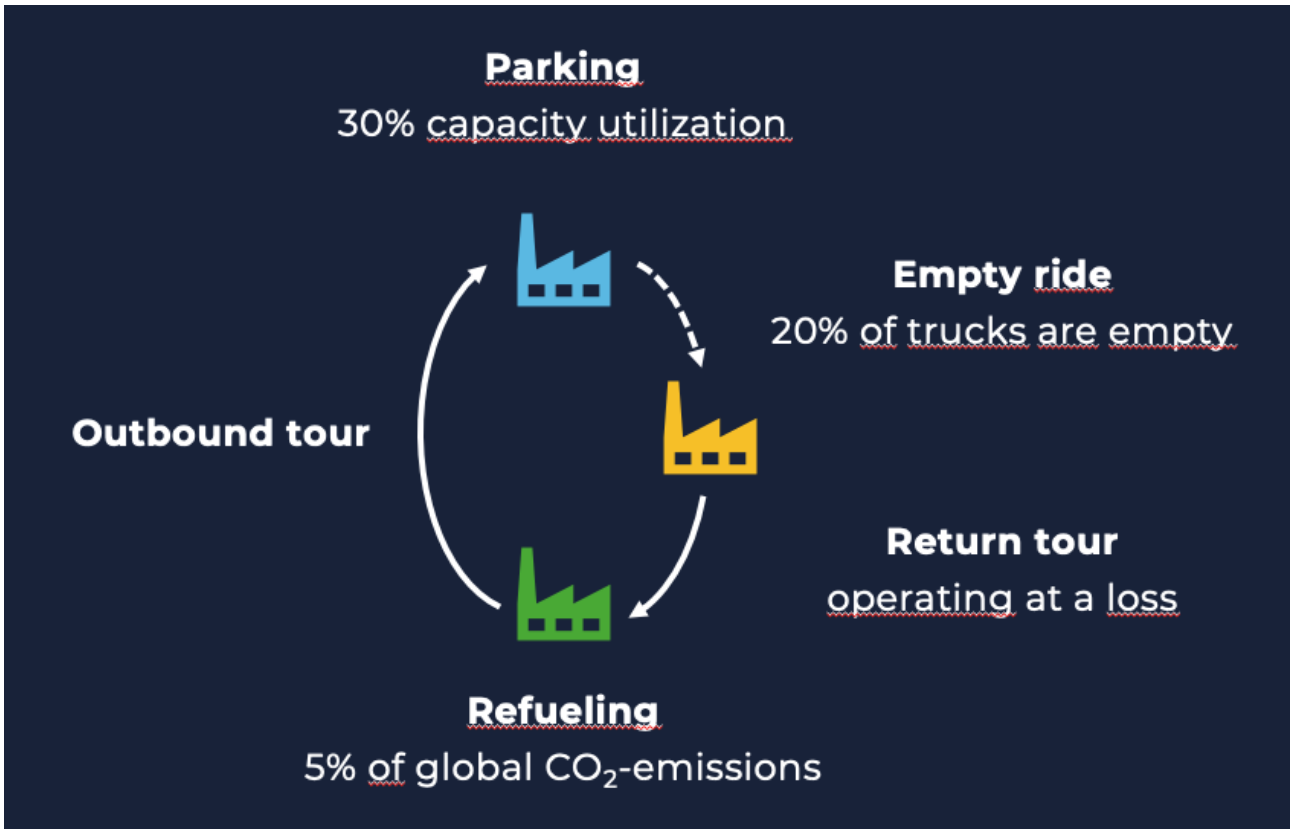
The concept of truck-to-truck relay transport is simple, and the underlying logistics approach has been known for centuries. Variants of relay transport were already employed by the Ancient Romans and later by the Thurn and Taxis family in establishing their postal network across Europe.

Today, truck-to-truck relay transport in long-distance road transport offers an innovative solution to some of the most pressing challenges faced by modern road freight logistics, including driver shortages, low truck utilization, high numbers of empty miles, and the limited usability of electric trucks for long-distance routes.

Challenges in long-distance road transport

Typically, a long-distance trip unfolds as shown in Figure 1:

Figure 1: Challenges on long-distance road transportation



After completing the outbound leg of a journey, the driver is required to take a mandatory rest break of at least 11 hours. During this time, the truck remains not in use, leading to poor

asset utilization. The following day, the driver often drives back empty[1] to pick up a return load. These types of tours are still primarily executed using conventional diesel trucks. Notably, heavy-duty long-haul road freight transport (over 300 km) accounts for approximately 5% of global CO_2 emissions[2].

How cross-company truck relay transport works

In a cross-company truck relay system, transport orders of transports traveling in opposite directions—typically from two different freight forwarders—are matched. Semi-trailers, containers (with chassis), or swap bodies (with chassis) are handed over between trucks at designated handover stations, usually located at public or private parking areas mid-route, near the halfway point of each driver's shift.

After the handover, each driver returns to their home region with their own truck, now carrying the trailer of the partner company. The delivery is then completed on behalf of the other freight forwarder.

This model eliminates the need for return-load searches and significantly reduces parking-related congestion. It allows freight forwarders to operate their trucks in second shifts, improving cost-efficiency and creating additional revenue. Moreover, the trailer swapsystem makes it feasible to use electric trucks on selected long-distance segments. When multiple handovers are integrated into a relay chain, the total transport time from point A to point B can be reduced by nearly 50%.

Key benefits at a glance:

1. Lower CO_2 emissions

- Enables practical use of electric trucks for long-distance transport
- Eliminates detours typically needed to get return shipments

2. Higher economic efficiency

- Doubles truck utilization by enabling second-shift operations with new drivers
- Eliminates unproductive return trips by matching transport orders
- Cuts transport time in half in multi-handover scenarios (due to driver-trailer decoupling)

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[1] KBA 2022

[2] Statista, Janson: 2.1Gt/38Gt=5%

3. Improved working conditions for drivers

- More predictable time at home at the end of the shift
- No need to sleep in the truck cabin
- Reduced stress from finding a parking place and concerns over cargo theft during rest time

Figure 2: Relay transport is based on swapping trailers or containers along routes

Figure 3: Two trucks swapping trailers. Any empty parking space can serve as a handover station.

Figures 2 and 3 indicate that when equipment—such as a loaded semi-trailer—is handed over between drivers and trucks, a formal handover protocol is essential to ensure a secure and traceable transfer. This process, including the completion of the handover protocol, is carried out by the truck drivers themselves.

1.2 About MANSIO system

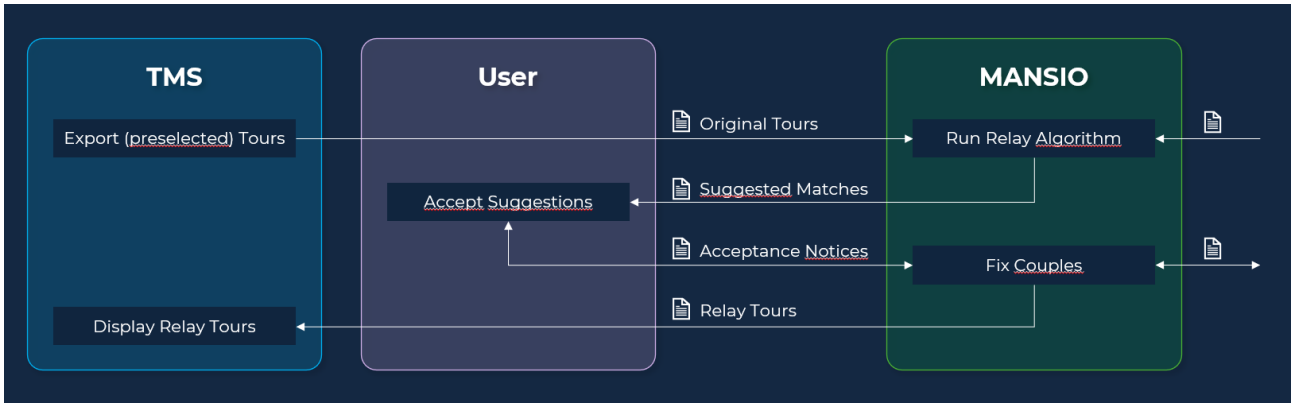
MANSIO is a logistics software company based in Aachen, Germany, offering a globally unique solution. The company provides a cloud-based, AI-powered B2B transport matching platform designed specifically for freight forwarders and carriers involved in heavy-duty long-haul road freight transport. MANSIO enables digitally supported, cross-company truck relay transport with trailer swapping.

Key features of the MANSIO system

AI-based transport order matching

Once transport orders are uploaded to the MANSIO platform—either manually or automatically via integration with the freight forwarders' Transport Management Systems (TMS)—an AI-driven algorithm matches orders based on optimal combinations of transport time, cost, and distance.

Figure 4: MANSIO`s interface with TMS systems



The matching process considers a wide range of operational and logistical constraints, including:

- Availability and current capacity of public and private handover stations
- Legal driving time restrictions
- Real-time traffic data and ETA calculations
- Order-specific requirements (e.g., compatibility, pickup and delivery time windows)
- Alternative routing options
- Depot and delivery zone locations
- Estimated handover durations
- Network-specific constraints, such as cut-off times

If two transport orders are complementary, the system generates a detailed tour plan split into four sub-tours, with a designated handover station—adaptable in real-time based on live traffic data.

This plan is sent to both freight forwarders' dispatchers for confirmation. Once approved, detailed instructions are shared with the respective truck drivers.

Operations Management in cross-company relay transport

The MANSIO Relay System supports dispatchers and truck drivers in their operative business with the following services:

- Tour Manager including tour schedule, driver communication and service tickets
- Live Tracker including position data, ETA (estimated time of arrival) and alerts
- Booking of park and charge infrastructure
- Control functions including KPI-dashboards for dispatchers, network manager and management

Financial clearing service

Upon completion of the tours, MANSIO also facilitates automated financial clearing between the involved freight forwarders and carriers through its platform.

Building a European Relay Transport Network

MANSIO's truck-to-truck relay system enables regional carriers—those focused on specific corridors or geographic zones—to become more active participants in international long-haul transport.

MANSIO's vision is to establish a Europe-wide network of trusted carriers working within this model. By collaborating with infrastructure providers such as parking facility operators, logistics terminals, and EV charging station providers, MANSIO aims to develop a reliable network of certified handover stations across the continent.

Figure 5: Multi-stage relay route from Antwerp to Vienna, using various MANSIO handover stations

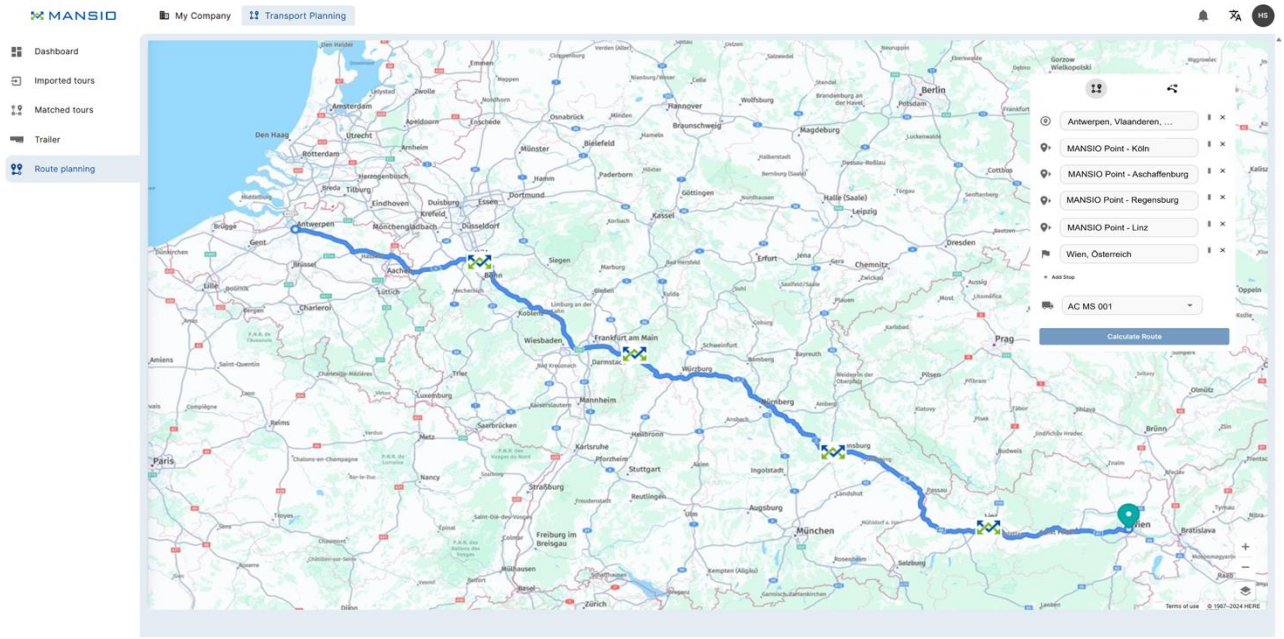
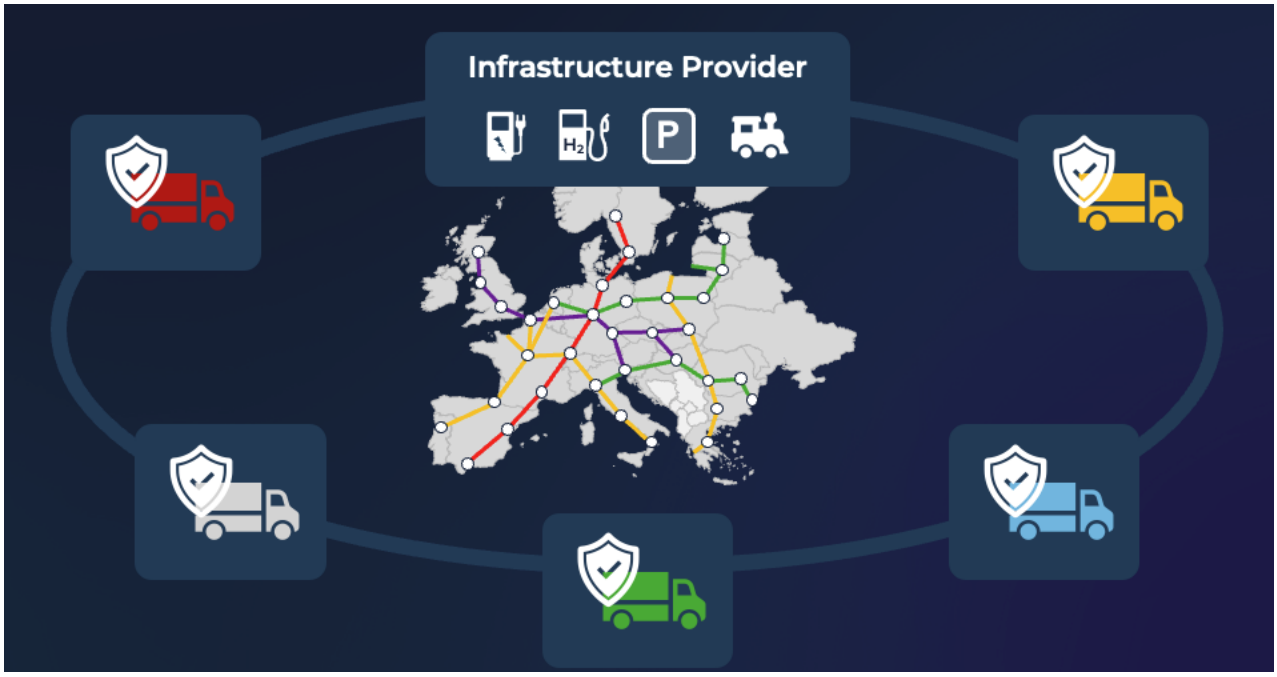


Figure 6: MANSIO ecosystem connecting carriers and infrastructure providers



1.3 Relay Transport for disruption handling in multimodal networks

Truck-to-truck relay transport offers a powerful new routing alternative to bridge disruptions between two terminals. In such cases, relay transport serves as a fast and flexible replacement solution.

Figure 8 illustrates a scenario in which a container arrives at Terminal A via barge, train, or truck. In comparison to the standard routing in figure 7, due to a disruption — such as for

example congestion, infrastructure failure, or weather — continuing the transport to Terminal B via the usual barge or rail connection is no longer possible. A new route is activated using the ReMuNet network.

In this scenario:

- The container is processed at Terminal A.
- It is then handed over to a local carrier arriving at Terminal A by truck.
- To bridge the long distance efficiently, the container is handed over again en route at a public or private handover station to another local carrier.
- This second carrier completes the tour, delivering the container either to Terminal B for further processing or—if possible—directly to the final consignee, bypassing Terminal B entirely.

Advantages of truck-to-truck relay transport in multimodal networks

Truck-to-truck relay transport provides a **f**lexible and time-efficient routing alternative that helps overcome disruptions in multimodal transport networks. Key benefits include:

- Enables quick re-routing to another terminal or directly to the consignee in case of blocked or delayed transport link.
- Multi-stage (multi-handover) relay transport can reduce total transport time by up to 50% compared to conventional long-haul trucking.
- By involving local carriers and SMEs, even for only part of the route, the system expands the pool of available transport capacity and introduces more flexibility and resilience in alternative route planning.
- Public and private handover stations along the road network are activated as strategic handover points, enabling dynamic re-routing without requiring new infrastructure investment.

Figure 7: Planned route to consignee along different transport modes

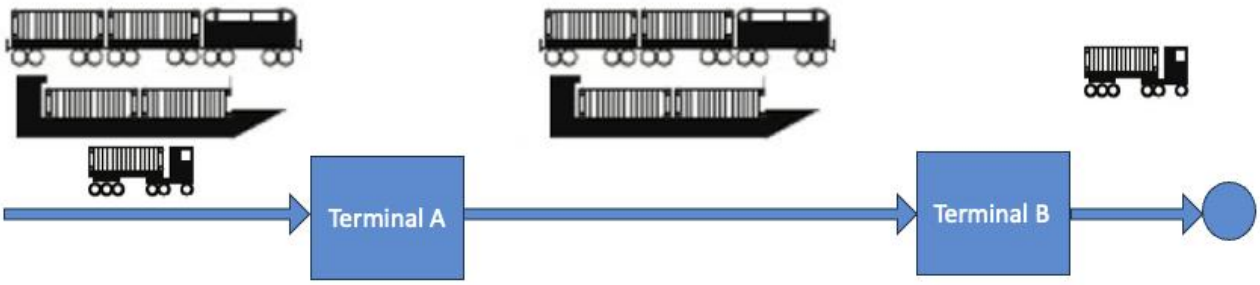
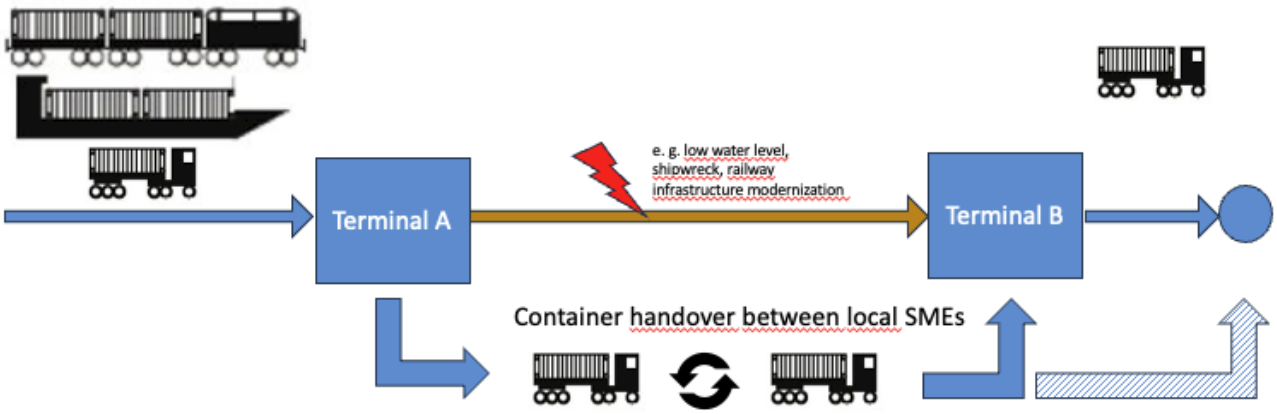


Figure 8: Relay transport as routing alternative to bridge disruptive event



2. Handover processes at terminals – „Gate-In“ & „Gate-Out“

A container terminal is a specialized facility designed for the handling, transfer, and temporary storage of cargo containers and other intermodal loading units. These terminals function as critical hubs in the global logistics network, enabling the seamless movement of goods between different modes of transport—ships, trucks, and trains. They are equipped with infrastructure such as container cranes, reach stackers, and designated storage yards to efficiently manage large volumes of freight.

When trucks deliver a container to a terminal, they must go through a "Gate-In" process. This process allows the truck to enter the terminal premises and drop off the container at the designated terminal yard, where it will be prepared for further transport by train or ship.

Conversely, trucks picking up containers that have arrived by train or ship must also pass through this procedure—commonly referred to as the "Gate-Out" process.

The Gate-In process typically includes:

- Truck registration at the terminal gate
- Document verification (e. g., transport orders, container numbers)
- Condition check and visual inspection of the loading unit to record any damages

Figures 11 and 12 below illustrate the types of equipment—such as container cranes and reach stackers—used for loading and unloading intermodal units onto or from trucks.

Again, once the loading or unloading is complete, trucks leave the terminal through the Gate-Out process. This may also involve a final inspection of the container, especially if the truck is picking up a full unit from the terminal.

The following figures 9 and 10 outline a typical **Gate-In and Gate-Out process** for a delivering truck or a truck picking up goods from the terminal.

Figure 9: Simplified Gate-In process

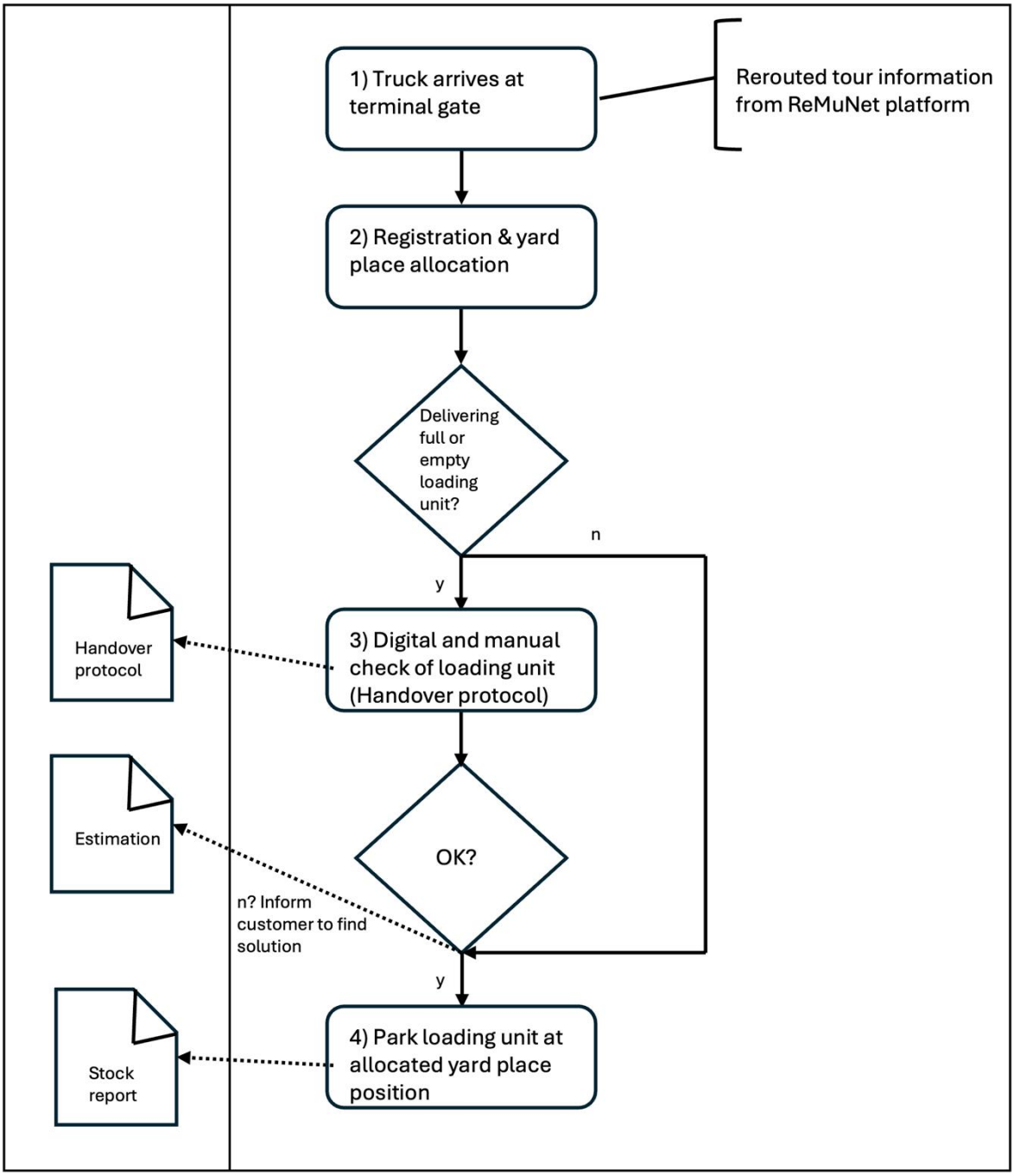
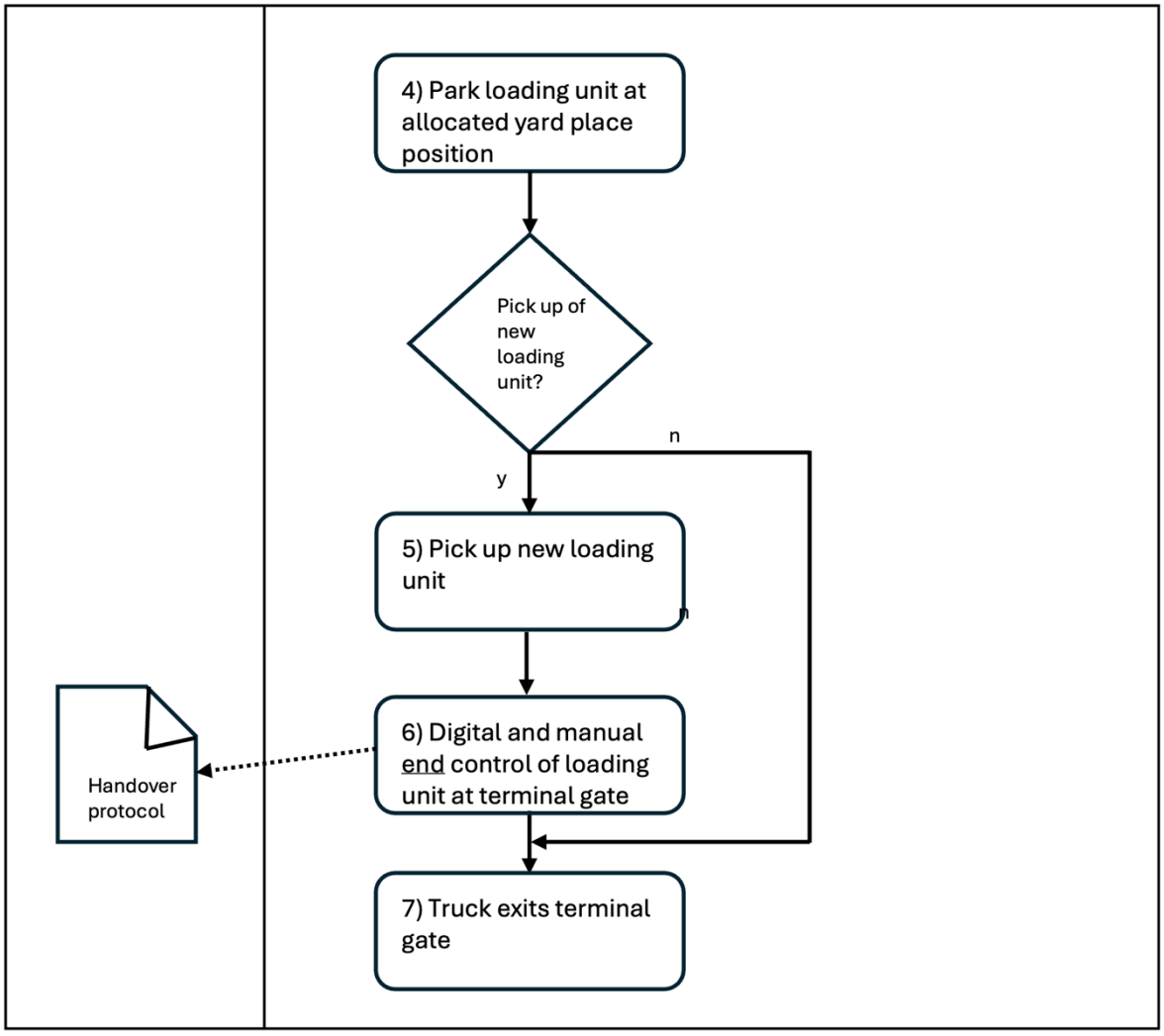


Figure 10: Simplified Gate-Out process



Before a loading unit is dropped off at the terminal or picked up by a truck, a condition check is required (see step 3 and 6 in the diagrams). The following inspections are commonly carried out depending on the type of loading unit:

For containers:

- Verification of container number as unique identifier
- Check for presence and correct identification of seals and seal IDs
- Photo documentation of the container
- Assessment of whether the container is in a transport-safe condition; report of any visible damage
- Handover and validation of freight documents
- Verification of ADR (hazardous goods) labelling, if applicable for the transport

For cranable semi-trailers:

- Verification of license plate or ILU-Code (as a unique identifier)
- Check if seal cord is properly tensioned
- Photo documentation of the semi-trailer
- Assessment of whether the semi-trailer is in a transport-safe condition; report of any visible damage

- Handover and validation of freight documents
- Verification of ADR labelling, if applicable

Due to large volumes and strict timetables for train and ship loading/unloading, container terminals often operate under significant time pressure. To streamline processes, many of the above checks are increasingly supported by digital technologies, reducing the need for manual inspection.

For example, automated systems such as light barriers at terminal entry and exit points can:

- Capture images for documentation
- Recognize and log the container number
- Identify visible damage
- Record the vehicle's passage automatically

To complement existing infrastructure, the ReMuNet handover protocol mobile application offers an on-demand, fully manual digital handover process.

The handover data is then transmitted via API to backend systems such as the ReMuNet platform, ensuring a secure, traceable, and standardized container or trailer handover at the terminal.

Figure 11: Container bridge with waiting truck

Figure 12: Reach stacker loading a truck with a 2 TEU container

3. Handover processes at roadside handover stations

As part of the ReMuNet project pilot**,** the focus is on developing digital handover solutions for two common types of intermodal loading units, cranable semi-trailers (see figure 13) and 40-foot containers (2TEU)**.**

For the road transport of a 40-foot container, an appropriately sized container chassis is required (see figure 12). During the handover process, the entire unit—container plus chassis—is handed over from one truck to another.

In contrast, cranable semi-trailers do not require an additional chassis**,** as they are self-supporting units.

Handovers can be carried out at any suitable public or private parking area**.** To perform a handover, only two adjacent truck parking spots are needed to ensure a smooth and efficient transfer between vehicles. Within its relay system, MANSIO utilizes public parking areas along motorways as well as private parking facilities from partner providers. The private parking locations are integrated into the MANSIO platform and can be booked and managed via API**.**

Figure 13: Cranable semi-trailer

Step-by-step handover process:

Scheduling and Communication

- Both truck drivers receive the location and time for the handover at the designated station.
- A specific parking slot is assigned and communicated via the ReMuNet app (Tour details).

Arrival and Preparation

- Both trucks arrive at the same time.
- Each driver positions their vehicle in the designated slot and decouples their trailer or container unit.

Equipment Handover

- The intermodal loading unit (semi-trailer or container with chassis) is exchanged between the vehicles.
- Drivers perform inspections and document the condition using the handover protocol app.

Departure

- After the new unit is securely coupled to the towing unit, both drivers depart and continue their respective trips.

The entire handover process typically takes around 20 minutes.

Figure 14: Overview of handover process for a swap of a semi-trailer

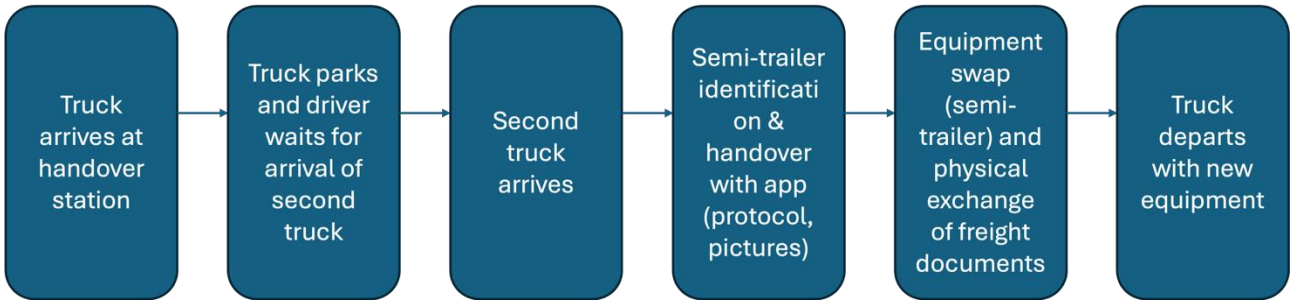
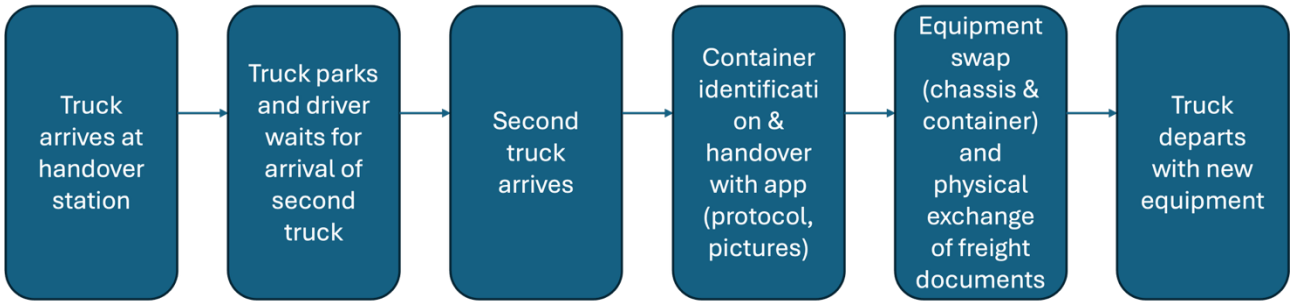


Figure 15: Overview of handover process for a container with container chassis



4. Navigation through mobile application prototype

Based on the requirements for a digital handover protocol that ensures safe and traceable rerouting via truck-to-truck relay transport, a mobile app prototype has been developed to support both truck drivers and terminal operators.

The app provides digital solutions for the handover of cranable semi-trailers and 2 TEU containers and is designed to be easily configurable for any other type of intermodal loading unit. It facilitates handover processes in three key scenarios: from a truck to a terminal (gate-in), from a terminal to a truck (gate-out), and directly between two trucks on the road (truck-to-truck).

As an example, this chapter walks through a typical truck-to-truck handover process using the app.

Table 1: Considered scenarios and equipment types

	Equipment type	
Scenario	**40ft container**	**Cranable semi-trailer**
Truck-to-truck	X	X
Truck to terminal (gate-in)/Terminal to truck (gate-out)	X	X

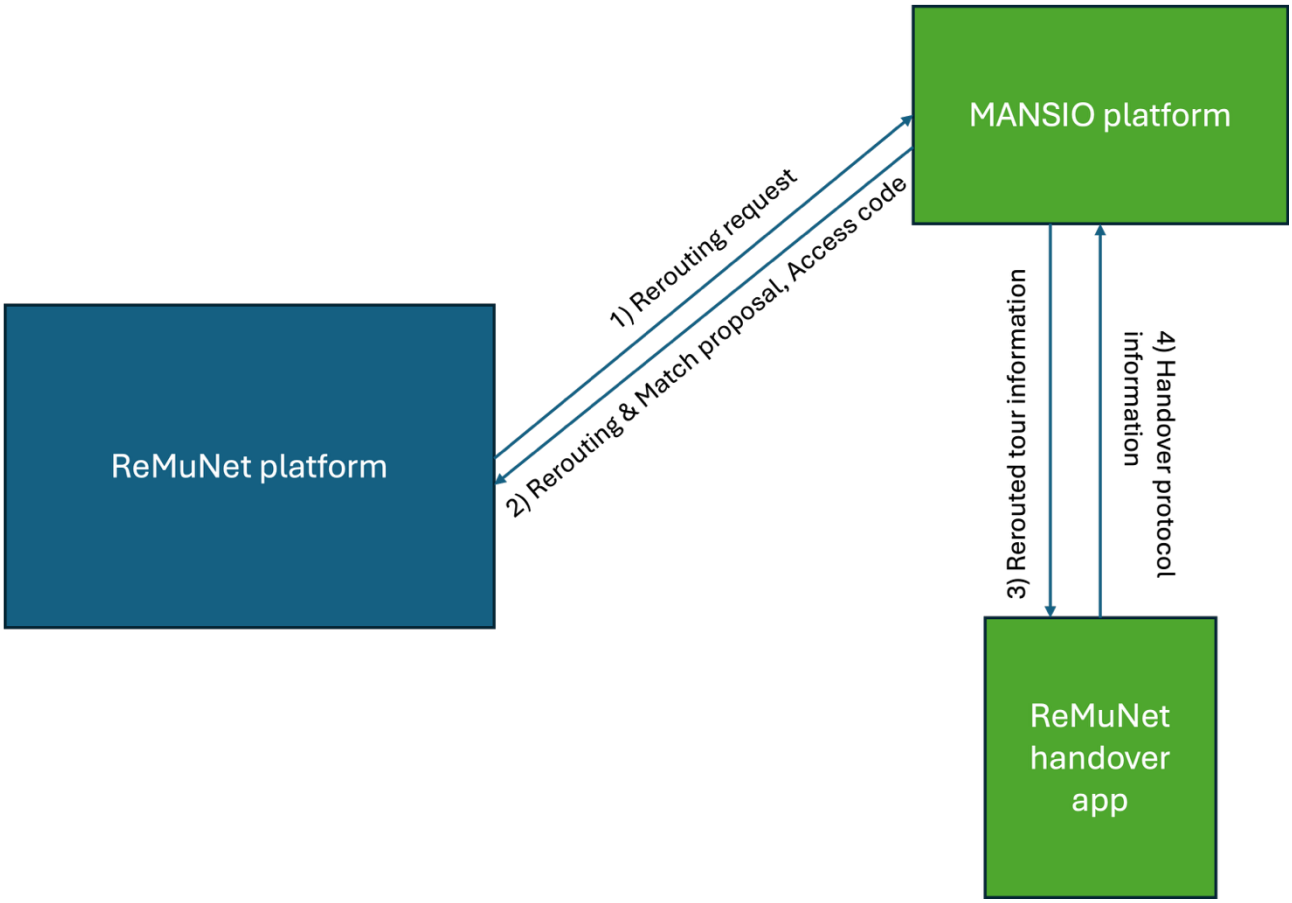
System integration: ReMuNet handover app and platform architecture

The ReMuNet handover app is fully integrable with the ReMuNet platform and communicates with the MANSIO platform, which serves as its backend system.

The process begins with transport orders streamlined in the ReMuNet platform. A rerouting request is sent to the MANSIO platform, which matches relevant transport orders and generates a rerouting proposal. This proposal is then returned to the ReMuNet platform for evaluation. Once accepted, the updated tour information is transmitted via MANSIO platform to the ReMuNet handover app, where it is processed by operational personnel involved in the handover procedure.

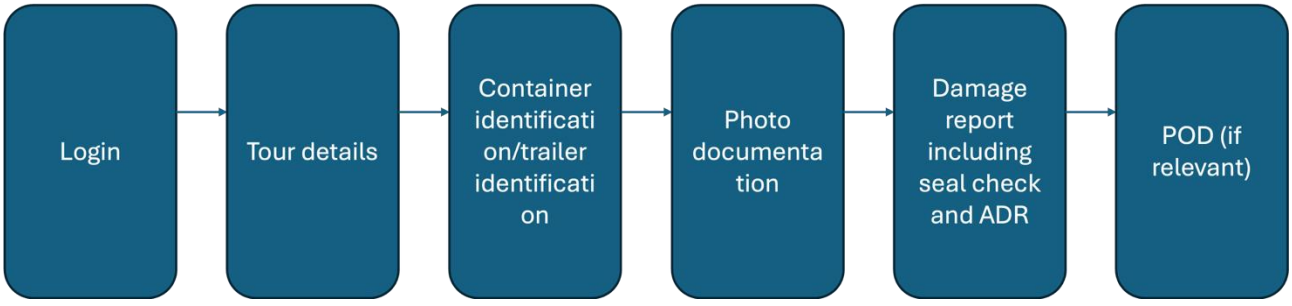
After a successful handover, the app generates a digital handover protocol containing all required data. This protocol is then sent back to the MANSIO backend and ReMuNet platform, ensuring complete traceability and documentation within the overall logistics workflow.

Figure 16: System integration



The following sub-chapters walk through the individual elements and process steps involved when a truck driver uses the ReMuNet handover app. The trip begins with a secure login process, after which the driver gains access to all relevant tour details. The handover workflow then continues with the identification of the container or trailer, followed by photographic documentation of the loading unit.In the final steps, any damages can be reported through the app's integrated damage reporting feature. Optionally, a Proof of Delivery (POD) document can be uploaded to complete the handover process (see Figure 17).

Figure 17: Overall handover workflow



4.1 Login process

The app supports multiple languages to ensure accessibility for a broad user base.

To ensure secure access, the app offers two login methods: users can log in either with a transport-specific access code or via email and password. Initial credentials (email and password) are provided by MANSIO to either the terminal operator or the carrier's dispatcher.

For truck drivers, a more practical login method is the use of a unique access code linked to a specific transport order. This code is generated by MANSIO and can be requested in advance of the rerouted tour, either via the ReMuNet platform or directly from MANSIO.

Figure 18: Two login methods

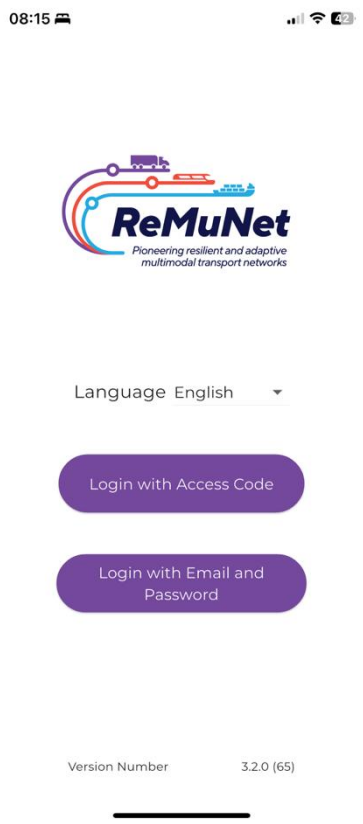


Figure 19: Different languages available

Figure 20: Login by password

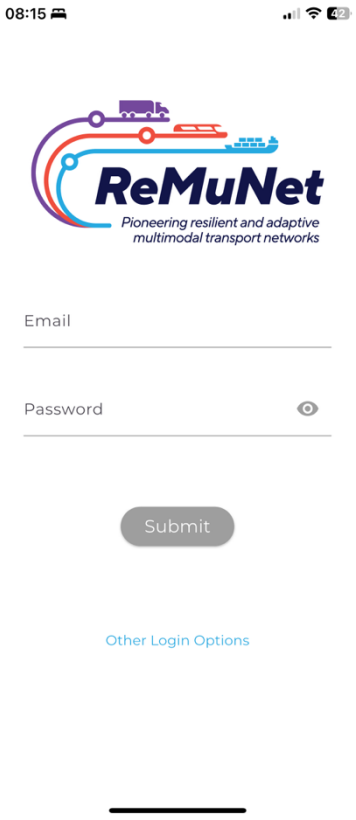
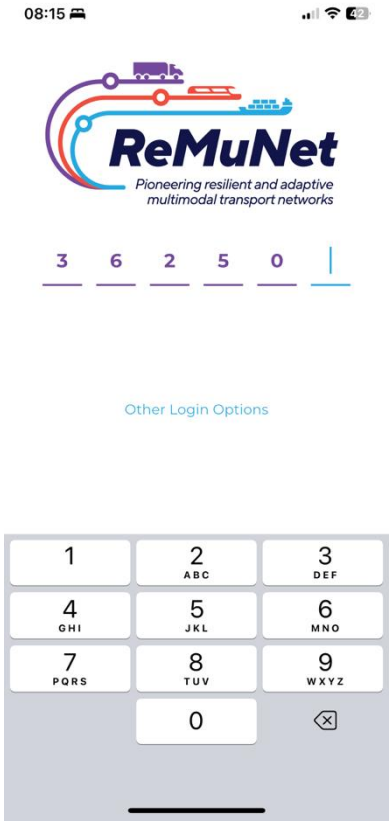


Figure 21: Login by transport-related access code and login process



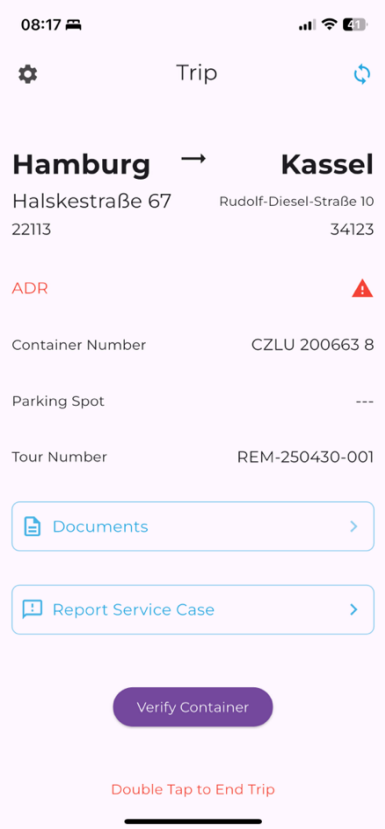
4.2 Tour details

After logging in, the truck driver is presented with all relevant details of the current rerouted tour. This information is retrieved in real time via API from the ReMuNet platform.

In the example shown, the tour involves a transport from a terminal in Hamburg to a handover station in Kassel, and is marked as an ADR transport. The driver can view any attached transport documents and has the option to upload additional documents directly through the app.

If any issues arise during the tour, the driver can also report a service case directly to the MANSIO software operator, ensuring fast communication and support.

Figure 22: Tour details screen



4.3 Container verification/trailer verification

A critical requirement during the handover process—whether at a dedicated handover station or during pickup/delivery at a terminal—is the accurate verification of the loading unit. This ensures that the correct container or cranable semi-trailer is identified and exchanged, minimizing operational errors.

To support this, the mobile app includes a number and text verification feature. Containers are uniquely identified by their container number, while cranable semi-trailers are verified using their license plate number.

Upon arrival at a handover station, the truck driver initiates the verification by selecting “Verify Container” within the app. The driver can then either capture a photo of the container number (or license plate, in the case of a trailer), or enter the identifier manually.

The process differs slightly depending on the scenario:

At terminal arrival, the terminal operator uses the app to identify the arriving truck and its associated loading unit.

For pickups at a terminal, it is the truck driver who uses the app to verify and confirm the correct container before departure.

Figure 23: Container verification feature

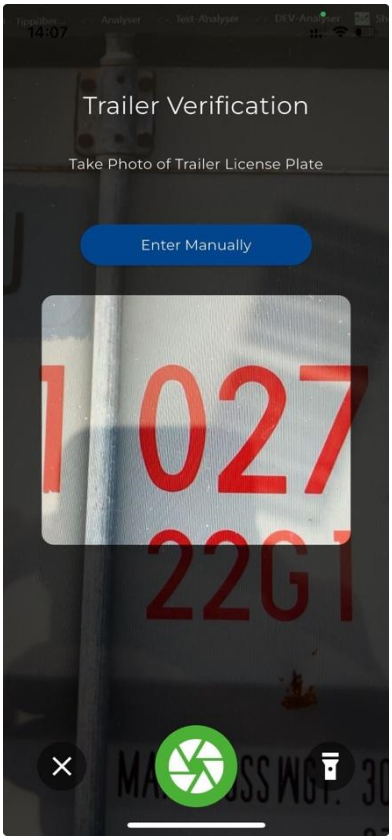


Figure 24: Manual container verification

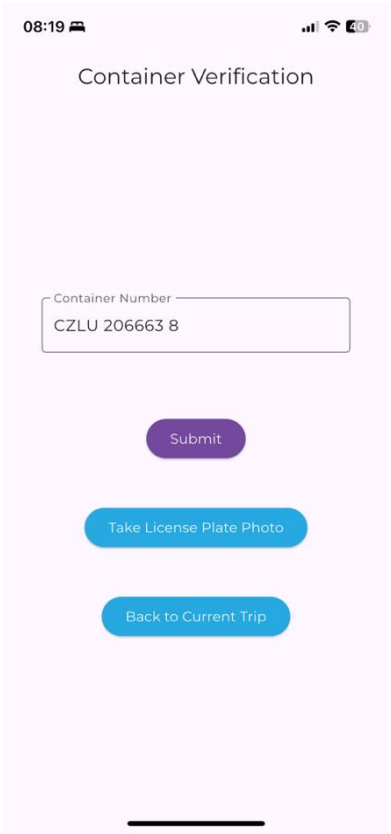
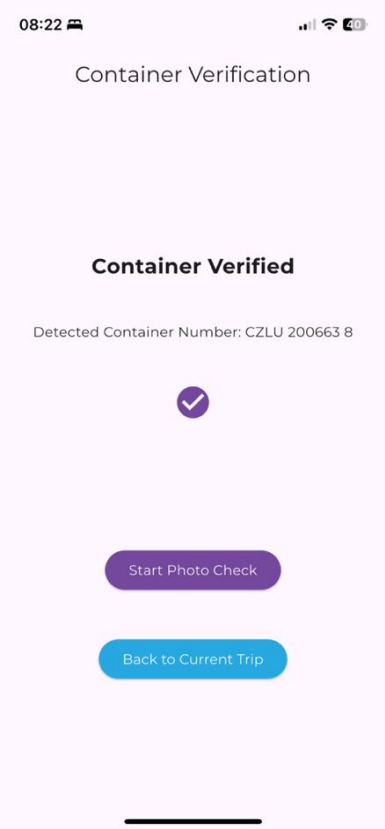


Figure 25: Container verification by cross-checking with transport data



Using the container number provided in the tour information from the ReMuNet platform, the app is able to verify the correct container. At this point, the photo verification check can begin.

Figure 26: Submitting photos

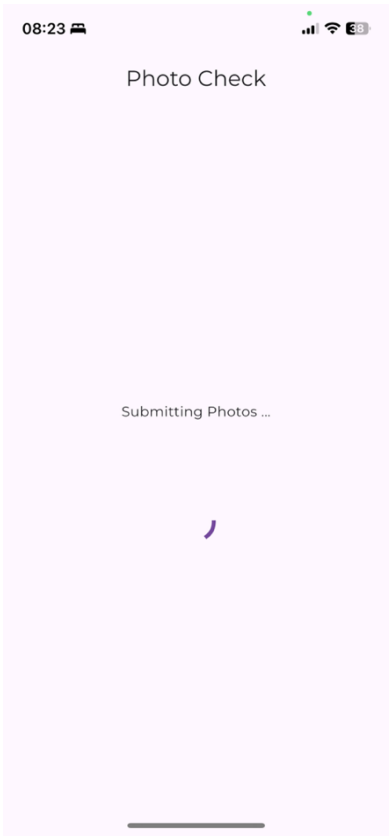
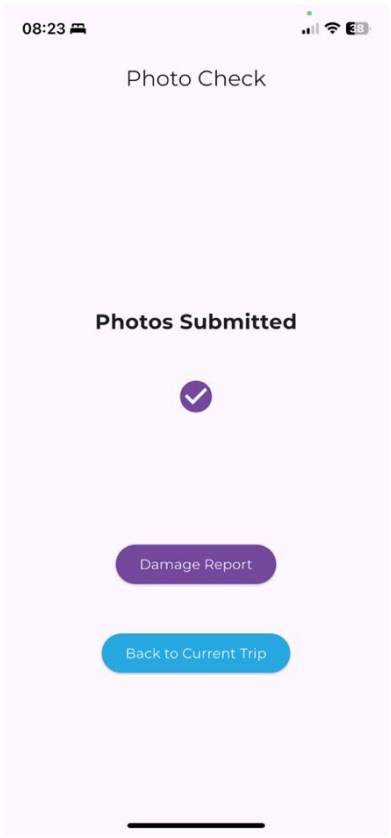


Figure 27: Photo check completed



A key requirement during the handover is to capture photos of the received container or cranable semi-trailer. The ReMuNet app guides the driver through this process in a simple and intuitive way. It is mandatory to take photos from four angles: front, rear, left side, and right side. Once all photos are taken, the driver submits them by clicking the „Submit Photos“ button.

4.4 Damage report including seal check and ADR

Based on extensive interviews with terminal operators and freight forwarders to understand the requirements of a comprehensive handover protocol, a detailed damage report feature has been implemented in the ReMuNet app.

The primary purpose of the damage report is to document any damages for insurance purposes and to ensure transport safety during the handover of equipment.

When completing a damage report, the following key questions must be answered:

- Is the container in a transport-safe condition?
- Are there any damages that need to be documented?
- Are the seals correctly placed, and are the seal IDs accurate?
- For ADR shipments: Is the ADR labeling correct?

The user can select “Report Damage” within the app to choose damage types from a predefined list. If no damage is present, the option “No Damage” can be selected.

Additionally, the user may add a description and attach photos related to the damage. Missing or incorrect ADR labeling can also be reported as damage.

Finally, a seal check is mandatory. The app allows uploading photos of the seals with their IDs to verify that the correct number and type of seals are protecting the transport unit. For cranable semi-trailers, a seal cord check is typically required, which can be confirmed by ticking the box labeled “I confirm that the seal cord is correctly attached.”

Figure 28: Report damage option

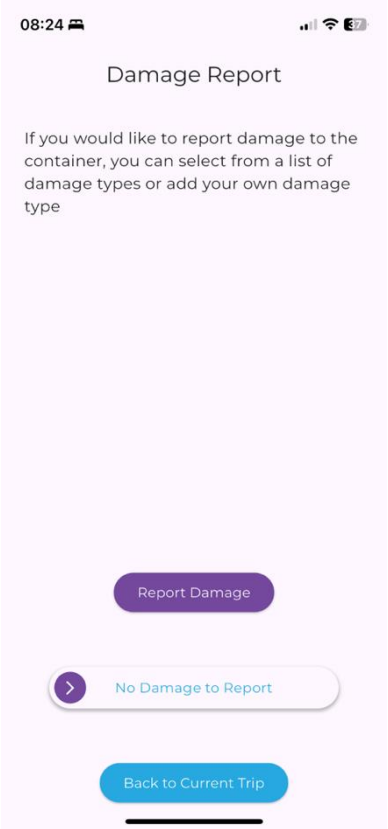


Figure 29: Select damage area

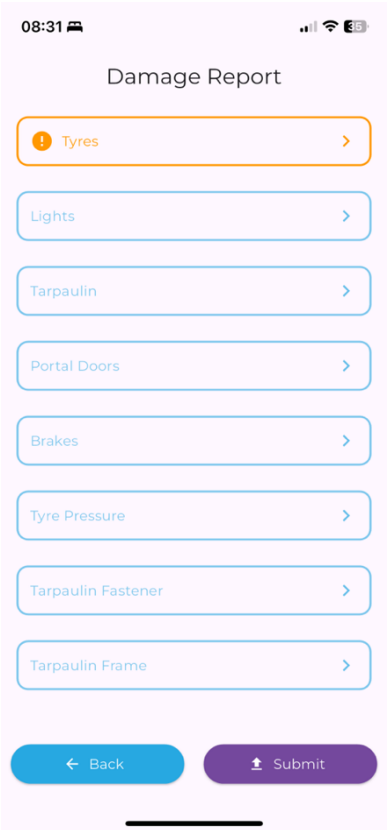


Figure 30: Manual damage report

Figure 31: Seal check

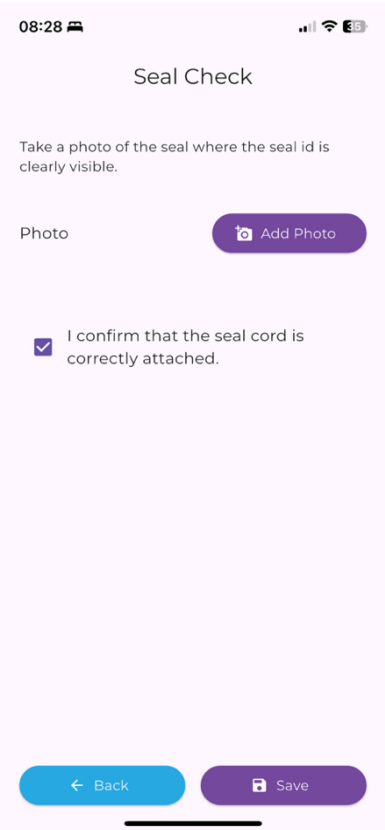
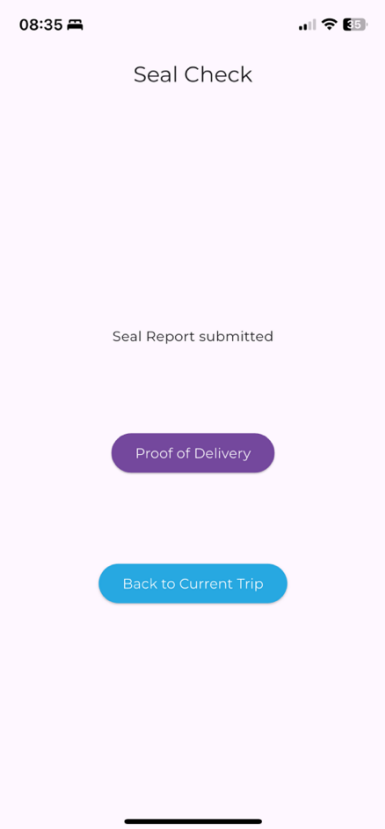


Figure 32: Seal report submitted



4.5 POD upload function

Finally, after a rerouted tour between Terminal A and Terminal B by trucks, the goods are delivered either at Terminal B or, when appropriate, directly to the consignee. To support this process, the app includes a POD upload feature.

This functionality enables users to digitally upload a photo of any POD document directly through the app. The uploaded document and its information are then processed within the platform's backend system, streamlining documentation and record-keeping.

Additionally, this feature can be used for the digital handover of any freight-related documents, further enhancing the app's versatility in managing transport documentation.

Figure 33: Selection of shipment

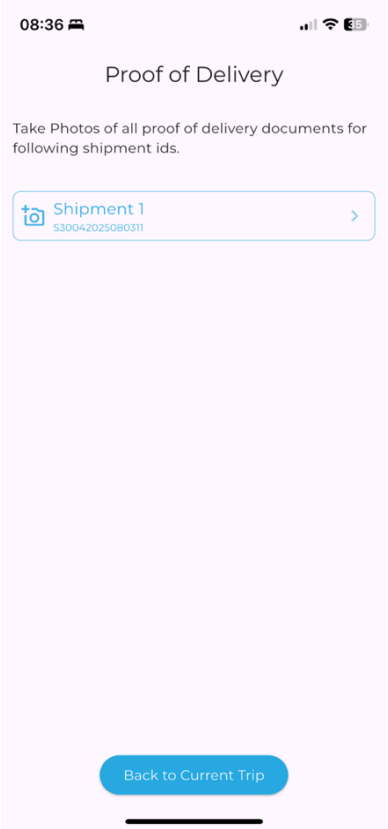


Figure 34: Capturing a picture for POD upload

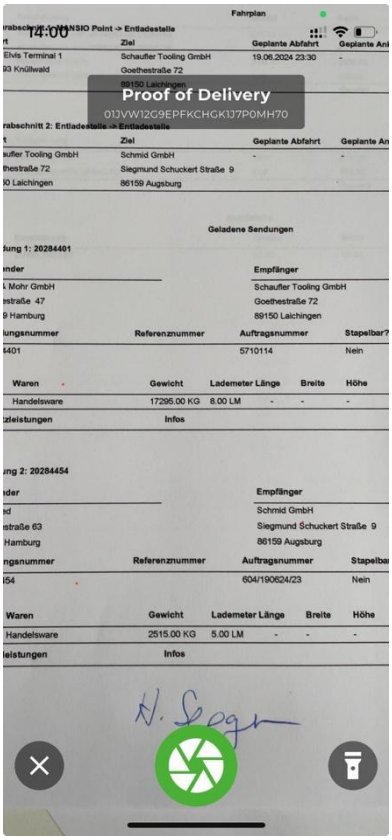
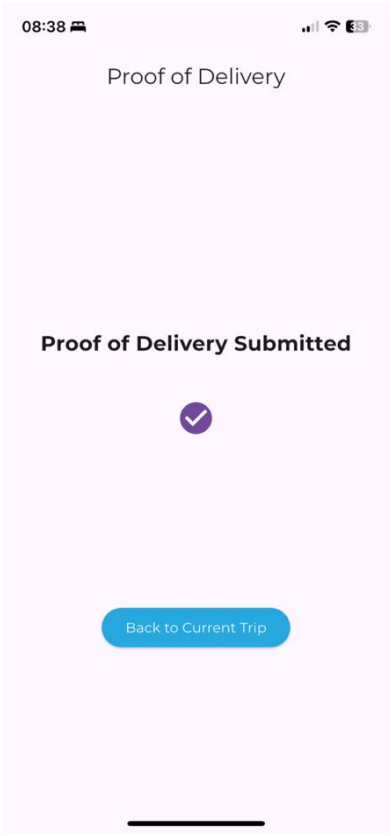


Figure 35: POD submission



5. Conclusion and Outlook

The truck-to-truck road relay transport system with trailer swapping, developed by the software company MANSIO, presents an innovative approach to overcoming disruptions in multimodal transport networks. By bridging blocked connections between terminals, it enables alternative routing options and facilitates the integration of local carriers into larger multimodal ecosystems.

Secure and traceable equipment transfers are ensured through standardized handover protocols. These protocols define the requirements for transferring intermodal loading units—such as containers and cranable semi-trailers—both at terminals (e.g., from barge or train to truck via terminal) and during truck-to-truck roadside handovers.

As part of the ReMuNet project, a configurable mobile application prototype has been developed to assist operational staff during these handovers. Designed specifically to meet intermodal transport requirements, the app interfaces with the ReMuNet platform, transmitting real-time handover data for documentation and traceability.

Unlike relay transport, standard modal transfers—such as truck-to-barge or truck-to-train—common in intermodal systems, involve transshipment at logistics hubs and do not involve continuous handovers. These transfers are conducted under distinct operational frameworks, often with formal protocols to ensure cargo integrity, legal accountability, and traceability.

Nevertheless, the ReMuNet handover app, while tailored for truck-to-truck relays, is adaptable to standard intermodal transfers through its configurable protocol options. Looking ahead, the relay transport logic could also be extended to direct barge-to-barge or train-to-train handover operations, enabling the app to serve as a mobile tool for supporting and documenting handovers.

The project

ReMuNet identifies and signals disruptive events and assesses their impact on multimodal transport corridors. It reacts quickly and seamlessly upon disruptive events in real-time. It supports TMS providers to improve route planning resilience. ReMuNet communicates alternative, pre-defined, multimodal transport routes to logistics operators and subsequently to truck drivers, locomotive drivers and barge captains. Through this, it enables a faster and adaptive multimodal network response. ReMuNet orchestrates route utilization, suggests transshipment points and optimizes capacity allocation, minimizing damage and shortening the recovery time. What is ReMuNet's core objective? As trailblazer for the Physical Internet, ReMuNet pursues the vision to enable and incentivize synchro-modal relay transport on European rail, road, and inland waterways to increase the holistic network resilience. It significantly reduces emissions and boosts freight transport corridor efficiency in case of disruptive events. stakeholders to ensure Europe-wide practicability and acceptance.
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